# Narrative Explanation of Econometric Demand Equations for Market Dominant Products Filed with Postal Regulatory Commission on January 20, 2016

Prepared for the Postal Regulatory Commission

## Estimation of Econometric Demand Equations

### A. Basic Demand Equation

The econometric demand equations filed with the Postal Regulatory Commission on January 20, 2016 take the following form:

$$V_t = a \cdot x_{1t}^{e_1} \cdot x_{2t}^{e_2} \cdot \ldots \cdot x_{nt}^{e_n} \cdot \varepsilon_t \qquad \text{(Equation 1)}$$

where $V_t$ is volume at time t, $x_1$ to $x_n$ are explanatory variables, $e_1$ to $e_n$ are elasticities associated with these variables, and $\varepsilon_t$ represents the residual, or unexplained, factor(s) affecting mail volume.

In general, variables which are believed to substantially influence the demand for mail are introduced into an econometric equation as a quarterly time series in which the elasticity of mail volume with respect to the particular variable is estimated using a Generalized Least Squares estimation procedure. The explanatory variables considered here include Postal prices, measures of macroeconomic activity (e.g., retail sales, employment, investment), measures of mail trends (e.g., volume losses to electronic and Internet diversion), seasonal variables, and other variables as warranted.

The functional form of Equation 1 is used by the Postal Service because it has been found to model mail volume quite well historically, and because it possesses two desirable properties. First, by taking logarithmic transformations of both sides of Equation 1, the natural logarithm of $V_t$ can be expressed as a linear function of the natural logarithms of the $X_i$ variables as follows:

$$\ln(V_t) = \ln(a) + e_1 \bullet \ln(x_{1t}) + e_2 \bullet \ln(x_{2t}) + e_3 \bullet \ln(x_{3t}) + \ldots + e_n \bullet \ln(x_{nt}) + \ln(\varepsilon_t) \qquad \text{(Equation } 1_L\text{)}$$

Equation $1_L$ satisfies traditional least squares assumptions and is amenable to solution by Ordinary Least Squares. Second, the $e_i$ parameters in Equation $1_L$ are

exactly equal to the elasticities with respect to the various explanatory variables. Hence, the estimated elasticities do not vary over time, nor do they vary with changes to either the volume or any of the explanatory variables. Because of these properties, this demand function is sometimes referred to as a constant-elasticity demand specification.

For explanatory variables which are logged in the equation, then, the coefficients which come out of these demand equations can be interpreted directly as elasticities.

## B. Explanatory Variables

### 1. Price

#### a. Own-Price Measures

The starting point for traditional micro-economic theory is a demand equation that relates quantity demanded to price. Quantity demanded is inversely related to price. That is, if the price of a good were increased, the volume consumed of that good would be expected to decline, all other things being equal.

This fundamental relationship of price to quantity is modeled in the Postal Service's demand equations by including the price of postage in each of the demand equations estimated by the Postal Service for mail categories and services which have a price (i.e., excluding Postal Penalty mail and Free for the Blind and Handicapped Mail).

The Postal prices entered into these demand equations are calculated as weighted averages of the various rates within each particular category of mail. For example, the price of First-Class single-piece letters is a weighted average of the single-piece stamped letters rate (49 cents), the single-piece metered letters rates (48.5 cents), the additional ounce rate (22 cents), and the nonstandard surcharge (22 cents)[1]. Product-by-product billing determinants provide the components of the market baskets which are used as weights in developing these price measures. The price indices used in the

[1] Rates as of January 20, 2016.

demand equations filed with the Commission on January 20, 2016, were constructed using FY 2014 billing determinants.

Looking at the historical relationship between mail volumes and Postal prices suggests that mailers may not react immediately to changes in Postal rates. For some types of mail it may take up to a year for the full effect of changes in Postal rates to influence mail volumes. To account for the possibility of a lagged reaction to changes in Postal prices on the demand for certain types of mail, the Postal price may be entered into the demand equations lagged by up to four quarters. The exact number of lags used is an empirical question which is answered on a case-by-case basis.

Prices are expressed in the Postal Service's demand equations in real dollars. The consumer price index (CPI-U) is used to deflate the prices.

In general, when the Postal Service refers to own-price elasticities, the reference is to long-run own-price elasticities. The long-run own-price elasticity of a mail category is equal to the sum of the coefficients on the current and lagged price of mail in the relevant demand equation. The long-run own-price elasticity therefore reflects the cumulative impact of price on mail volume after allowing time for all of the lag effects to be felt.

### b. Other Price Measures

The price of postage is not the only price paid by most mailers to send a good or service through the mail. For those cases where the non-Postal price of mail is significant and for which a reliable time series of non-Postal prices is available, these prices may also be included explicitly in the demand equations used to explain mail volume, although there are no such examples in the demand equations presented here.

### c. Postal Cross-Price Relationships

Historically, several of the Postal Service's econometric demand equations have included cross-price measures with other Postal products, such as First-Class single-piece and workshared letters, and Bound Printed Matter and Media Mail. In some cases, these cross-price variables entered the equations in the same way as the own-price variables, i.e., as a measure of the average price of the product. In other cases, however, cross-price variables were measured in relative terms (i.e., the difference between the prices of two Postal products).

As has been the case for several years now, the econometric demand equations filed with the Postal Regulatory Commission on January 20, 2016, do not include any such cross-price variables. The exclusion of such variables was first discussed in some detail in the response to the Chairman's Information Request No. 8, question 5, which was filed with the Commission on March 8, 2010. As explained in that response, the decision of whether or not to include a particular cross-price relationship in a particular econometric demand equation was made on a case-by-case basis. In all cases, the overriding goal of all of the Postal Service's econometric work is to produce the most accurate volume forecasts possible. As a general rule, the most accurate volume forecasts are obtained from econometric demand equations which best model the historical demand for mail volume. So, while it ended up being the case that, in fact, there were no cross-price or discount variables included in any of the econometric demand equations filed on January 20, 2016, this was not the result of a general decision to exclude all such variables from the Postal Service's equation, but was, instead, the result of a series of careful analyses of each of the Postal Service's individual demand equations.

This is not, however, to say that mailers may not at times shift from one mail subclass to another in response to a change in Postal rates. In fact, however, such changes tend to overwhelmingly be responses to specific and unusual changes in

relative rate structures associated with a specific rate change. Rather than attempting to model such changes through a blunt one-size-fits-all instrument such as an aggregate price index or an average discount level, the effect of such changes is, instead, better modeled through the inclusion of either dummy variables or non-linear Intervention analysis. Examples of such case-specific mailer shifts between mail subclasses include the impact of R97-1 and R2006-1 on Standard Regular and ECR mail volumes and the impact of MC96-1 on Standard Nonprofit and Nonprofit ECR mail volumes.

## 2. Impact of the Economy on Mail Volumes

In addition to being affected by prices, mail volumes are also affected by the state of the economy. For example, as incomes rise, consumers are able to consume more, and this is generally true of Postal services which tend to rise during periods of strong economic growth and stagnate or decline during recessions. A stronger economy is also likely to increase business use of the mail. To model these relationships, the demand equations used by the Postal Service typically include one or more macroeconomic variables which relate mail volumes to general economic conditions.

### a. Macroeconomic Variables Used Here

Four key macroeconomic variables are used in the Postal Service's econometric market-dominant demand equations: employment, investment, mail-order retail sales, and exports. These data are compiled by the United States government and are obtained by the Postal Service from IHS Global Insight, an independent economic forecasting firm. At various times, consumption expenditures, personal disposable income, gross domestic product (GDP), and the difference between actual and potential GDP (the output gap) have also been explored as candidate explanatory variables.

The specific variable choices are made on an equation-by-equation basis. The decision process in choosing macroeconomic variables includes an effort to develop equations which are both theoretically correct as well as empirically robust.

**(1) Employment**

Total private employment is included in several of the Postal Service's econometric demand equations, including First-Class single-piece and workshared letters, cards, and flats; Periodicals mail; Money Orders; and Post Office Boxes. Employment is an excellent measure of the overall level of business activity in the economy. In many cases, mail volume is not affected by the dollar value of economic transactions, so much as by the number of such transactions. For example, the number of credit card bills one receives does not necessarily go up as the total amount charged per card goes up. While variables like GDP or retail sales may be good measures of the total dollar amount of economic activity (e.g., the total amount charged per credit card), employment appears to be a better measure of the number of business transactions (e.g., number of credit card bills received).

Ultimately, the choice of which macroeconomic variable to use in a demand equation is an empirical decision based on which variable best fits the volume data.

**(2) Total Real Investment**

Advertising can be viewed as a type of business investment. As such, direct-mail advertising volume is likely to be affected by the same factors which drive business investment spending. To reflect this relationship, real gross private domestic investment is included as an explanatory variable in the demand equations for Standard Commercial mail (Regular and ECR) filed with the Commission on January 20, 2016.

#### (3) E-Commerce Sales

Bound Printed Matter and Media Mail volumes consist, in large part, of the delivery of products bought by the sender or recipient of the mail. This type of mail volume derives almost directly from retail sales. More specifically, package delivery services are largely a function of retail sales which are generally purchased online and which are then delivered to the consumer. Hence, e-commerce sales are included directly in the demand equations for Bound Printed Matter and Media and Library Rate Mail to reflect this direct relationship between e-commerce retail sales and these mail volumes.

#### (4) Exports and Exchange Rates

As the primary indicator of outgoing international trade, the exports variable characterizes the type of economic activity that generates outgoing international mail of all classes. In particular, exports will generate business communications that are sent by International First-Class Mail. International mail volumes may also be affected by exchange rates, which may make the price of foreign goods more or less attractive relative to the price of similar domestic goods.

### 3. The Internet and Electronic Diversion

One of the most significant issues facing the Postal Service in recent decades has been the threat, both realized and potential, of electronic diversion of mail. E-mail has emerged as a potent substitute for personal letters and business correspondence. Bills can be paid online, and bills and statements can be received through the Internet rather than through the mail. Virtually all magazines and newspapers now have an online edition as a complement to their print editions, and in some cases, the print edition has been eliminated in favor of an all-online format. Understanding the emergence of the Internet and its role vis-à-vis the mail is critical in understanding mail volume, both today and in the future.

There are two general dimensions to the Internet which are important to understand in assessing the extent to which the Internet, and other electronic alternatives, may serve as possible substitutes for mail volume: the breadth of Internet usage and the depth of Internet usage.

### i. Breadth of Internet Use

The breadth of Internet usage refers generally to the number of people online. As more people use the Internet, there are simply more people for whom the Internet is available as a substitute for the mail.

Increases in the breadth of Internet use can explain a large share of historical electronic diversion. Moving forward, however, the breadth of Internet usage is unlikely to increase significantly because Internet penetration is levelling off in the United States at around 80 percent of the population.

### ii. Depth of Internet Use

The depth of Internet usage refers to the number of things which an individual does on the Internet. As the depth of Internet usage increases for a particular person, the number of activities for which the Internet can substitute for mail may increase, thereby increasing the overall level of substitution of the Internet for mail volume, even in the absence of an increase in the number of Internet users.

The breadth and depth of Internet usage have both been important in understanding the impact of the Internet on mail volumes historically. However, moving forward, the depth of Internet usage is a much more important consideration. The reason for this is that the breadth of Internet usage has a natural ceiling. Eventually, everybody who would ever obtain Internet access will actually have Internet access. At that point, the only source of increasing electronic diversion of the mail will be an increasing depth of Internet usage. Hence, in measuring the impact of the Internet and other electronic

alternatives on mail volumes, it is important to measure the impact not only of the breadth of Internet usage in the United States, but the depth of Internet (and other electronic) usage as well.

### ii. Use of Trends to Model Internet Diversion

Beginning in the early 2000s, the Postal Service included one or more explicit measures of Internet usage in several of its demand equations as a means of capturing the impact of the Internet (and other electronic delivery alternatives) on mail volumes. These variables – which included consumption expenditures on Internet Service Providers, the number of households with Broadband Internet access, and the number of Global Internet Servers - reflected primarily the breadth of Internet use – i.e., the number of people on the Internet. As noted above, however, the story of Internet diversion of mail has more recently been a story of increasing depth of Internet use.

To better measure the increasing depth of Internet use, the Postal Service's methodology for modeling Internet and other electronic diversion has changed more recently. For the market-dominant demand equations filed with the Commission on January 20, 2016, diversion is not modeled via explicit Internet variables, but, instead, is measured through a series of linear time trends which start at various times within the sample periods over which the Postal Service's demand equations are estimated.

The use of trends to measure Internet diversion was discussed at length in Thomas Thress's responses to Presiding Officer's Information Requests (POIRs) in Docket No. R2013-11. See, for example, Mr. Thress's responses to POIR No. 3, question 1; POIR No. 6, question 12; and POIR No. 9, question 7 in that case.

Diversion trends of this kind are estimated in several of the Postal Service's demand equations, including all of First-Class Mail, Periodicals Mail, Media Mail, and Money Orders. Time trends of this type are special cases of Intervention Analysis. The technical details of Intervention Analysis are described later in this document.

### 4. The Great Recession

Even after one accounts for differences in the impact of long-run and short-run macroeconomic impacts on mail volumes, the most recent recession had a larger than expected negative impact on many categories of mail volume. Some earlier work at the Postal Service dealt with these unique impacts of the 'Great Recession' by looking at filtered macro-economic data, focusing on time periods where the "trend" component of these variables turned negative.

More recently, the Postal Service has attempted to model the unique impacts of the Great Recession on mail volumes using Intervention Analysis techniques. The technical details of Intervention Analysis are described next.

### 5. Intervention Analysis

In some cases, mail volumes may be affected by unique events, or "interventions". Oftentimes, the effect of such factors can be modeled via trend or dummy variables. In other cases, however, the impact of such "interventions" on mail volumes may be more complicated than can be fully captured by a set of linear variables. In such cases, a more elaborate non-linear Intervention analysis is undertaken to more accurately model the impact of some factors on some types of mail.

Two examples of Interventions for which this type of analysis is undertaken are the two factors just discussed: Internet Diversion and the Great Recession.

#### a. Non-Linear Intervention

Intervention analysis is a time series technique which allows one to identify the effects of an event over time. An "intervention" is an event which affects the demand for a given product. There are essentially three different types of impact of intervention events: step functions, pulse functions, and trends. A generalized Intervention Analysis

technique allows for a functional form which is flexible enough to accommodate all of these possibilities as dictated by the underlying data. This function is called the *transfer function*.

The role of the transfer function is to allow the input variable to affect the volume in different ways and rates over time. Therefore, the impact of an intervention on volume is the product of a particular transfer function and an input variable. The general form of the transfer function is given by:

$$I_t = \frac{\omega(B)}{\delta(B)} B^S \xi_t^T = \frac{\omega_0 - \omega_1 B - \omega_2 B^2 - \omega_3 B^3 ... - \omega_i B^i}{1 - \delta_1 B - \delta_2 B^2 - \delta_3 B^3 ... - \delta_3 B^j} B^S \xi_t^T \qquad \text{(Equation 4)}$$

where *B* is the lag operator: $B^S y_t = y_{t-S}$. For the stability of the model, the roots of the equations $\omega_0 - \omega_1 B - \omega_2 B^2 - .. - \omega_i B^i = 0$ and $1 - \delta_1 B - \delta_2 B^2 - .. - \delta_j B^j = 0$ must lie outside the unit circle. Of course, a more generalized form of Equation 4 is necessary to limit the number of ω and δ parameters so that the equation can be uniquely estimated.

The ω(B) terms represent the level impact of the intervention event. For example, in Equation 4, if $\omega_i$=0, for i>0, then the intervention will only affect volume in the current period, and Equation 4 will simplify to a dummy variable equal to one in the quarter of interest and zero elsewhere with coefficient $\omega_0$. If, on the other hand, $\omega_i = \omega_j$, for all i,j, with $\delta_i = 0$ for all i, then Equation 4 simplifies to a dummy variable equal to one from the quarter of interest forward with coefficient $\omega_0$ (=$\omega_i$ for all i). Finally, if $\omega_i$ is an increasing (or decreasing) function of i, then the transfer equation identified above will posit a trend response to the intervention event of interest.

The δ(B) terms represent the rate of increase or decrease of the intervention events, e.g., the rate of change from a short-run to a long-run impact. For simplicity, $\delta_i$ is typically assumed to be constant across all i. That is, the rate of adoption of an intervention event is typically assumed to be constant over time.

A transfer function that allows for each of the three possibilities outlined above - pulse, step, or trend response to an intervention – is shown in Equation 5 below:

$$I_t = \{\omega_0 + \omega_1 B / (1 - \delta B) + (\omega_2 + \omega_3 t)B / (1 - B)\}P_t \qquad \text{(Equation 5)}$$

where $P_t$ is a pulse function – i.e., $P_t = 1$ for the period of the intervention, zero elsewhere.

A step function (equal to 1 for the period of the intervention and all subsequent periods), $S_t$, can be expressed as a function of $P_t$ using lag notation so that $S_t = P_t / (1-B)$.

In Equation 5, $\omega_0$ is equal to the initial response to the Intervention event. If $\omega_1=\omega_2=\omega_3=0$, then the response to the Intervention will be equal to zero in all subsequent periods, and the transfer function will be a pure pulse function ($P_t$). If $\omega_0=\omega_1$ and $\delta=\omega_2=\omega_3=0$, then the transfer function will be a pure step function ($S_t = P_t / (1-B)$). If $\omega_1=\omega_2=0$ and $\omega_0=\omega_3$, then the transfer function will be a pure linear trend. If, on the other hand, none of these equalities are realized, then Equation 5 will explain a more flexible transfer function as dictated by the observed data.

The functional form of Equation 5, which expresses the transfer function as a function of the lag operators may not be intuitively obvious. Re-expressing the lag operator notation here into more conventional notation yields Equation 6:

$$I_t = \omega_0 \cdot P_t + \omega_1 \cdot (P_{t-1} + \delta^1 P_{t-2} + \delta^2 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \omega_3 \cdot T_t \cdot S_t \qquad \text{(Equation 6)}$$

where, as noted above, $P_t$ is equal to one during the period of the intervention, zero elsewhere (both before and after), $S_t$ is equal to zero prior to the intervention event being modeled, and equal to one thereafter, and T is a time trend equal to zero at the point of the intervention event, increasing by one each quarter thereafter.

While Equation 6 is a function of only 5 parameters – $\delta$ and $\omega_i$ for i = 0 to 3 – it nonetheless technically requires the inclusion of an infinite number of terms in the demand equation of interest. It turns out, however, that, at any given point in time, all of the $P_{t-i}$ terms is equal to zero except for, at most, one. To see this, one can re-write Equation 6 as follows

$$I_t = \omega_0 \cdot P_t + \omega_1 \cdot \sum_{i=1}^{\infty} (\delta^{i-1} P_{t-i}) + \omega_2 \cdot S_t + \omega_3 \cdot T_t \cdot S_t$$

When $T_t = 1$, the value of $P_{t-1} = 1$, $P_{t-i} = 0$, for all $i \neq 1$. Similarly, when $T_t = 2$, the value of $P_{t-2} = 1$, $P_{t-i} = 0$, for all $i \neq 2$. So, instead of a sum over all values of $P_{t-i}$ one can instead replace i with $T_{t-1}$ in the above equation. That is,

$$I_t = \omega_0 \cdot P_t + \omega_1 \cdot S_t \cdot (\delta^{T_{t-1}}) + \omega_2 \cdot S_t + \omega_3 \cdot T_t \cdot S_t \qquad \text{(Equation 7)}$$

Intervention variables of the form in Equation 7 are then added to the Postal Service's econometric demand equations as necessary. The Intervention parameters - $\omega_0$, $\omega_1$, $\omega_2$, $\omega_3$, and $\delta$ – are estimated simultaneous with the other econometric parameters using non-linear least squares.

As noted above, Intervention Analysis of this type is used to model unique aspects of the 'Great Recession' on several classes of mail, including First-Class Mail, Standard Mail, Periodicals Mail, and Bound Printed Matter. Other "interventions" which are modeled in this way include the impact of R97-1 rates (which priced Standard Regular automation 5-digit letters below ECR basic letters) on Standard Regular and ECR mail volumes. In this case, the initial impact was modestly strong, but the negative impact grew over time, as mailers gradually adapted their mailing procedures to take advantage of the lower Regular Automation rates.

**b. Time Trends**

Often the behavior of a variable that is being estimated econometrically is a function of other observable variables. For example, mail volume is a function of postal prices. Sometimes, however, the behavior of a variable is due to factors that do not easily lend themselves to capture within a time series variable suitable for inclusion in an econometric equation. In such cases, it is common for such phenomena to be modeled in part through the use of trend variables. For example, it has been found by the Postal Service (and others[2]) that trend variables do a better job of modeling the impact of electronic diversion on mail volume than specific measures of Internet usage, which do not necessarily reflect the gradual substitution of the Internet for correspondence and transactions which had previously been undertaken via the mail.

Given that trend variables are needed within particular demand equations, an equally important question becomes what forms these trend variables ought to take.

> A trend is a trend is a trend
> But the question is, will it end?
> Will it alter its course
> Through some unforeseen force,
> And come to a premature end?
>
> Sir Alec Cairncross

It is not sufficient to merely plug full-sample linear time trends into all of one's econometric equations. Rather, it is important to evaluate every demand equation individually and determine the appropriate trend specification for each equation, if any.

Many of the demand equations filed with the Commission on January 20, 2016, including the Periodicals Mail equation, all of the Standard Mail equations, and most of the Special Service equations, included full-sample linear time trends to account for

[2] e.g., Veruete-McKay, Leticia; Soteri, Soterios; Nankervis, John C.; and Rodriguez, Frank (2011) "Letter Traffic Demand in the UK: An Analysis by Product and Envelope Content Type," Review of Network Economics: Vol. 10: Issue 3, Article 10.

long-run trends in the volumes of these types of mail, for which economic sources do not readily lend themselves to inclusion in an econometric time series equation. Such long-run changes in mail volume are therefore most readily modeled by a trend variable.

Some of the Postal Service's demand equations include alternate trend specifications. The Delivery and Signature Confirmation equations, for example, include some logistic trend terms which more accurately reflect the rapid initial growth, the rate of which declines over time, which often characterizes the early history of new products. A similar logistic trend is also included in the First-Class workshared letters, cards, and flats equation to model the increasing usage of worksharing discounts by mailers in previous years, the rate of increase of which has slowed significantly more recently.

Finally, several equations include linear time trends over only a portion of their sample period. These trends capture new and changing influences which have affected mail volumes, including the introduction and expansion of Internet and other types of electronic diversion, as well as changes in long-run mail trends that were caused by the Great Recession. Trends of this nature are included, for example, in the demand equations for First-Class Single-Piece and Workshared letters, cards, and flats; Periodicals Mail; Media and Library Rate Mail; as well as Money Orders.

Time trends of this type are special cases of the non-linear intervention analysis outlined above.

**c. Dummy Variables**

In some cases, the effect of specific events may be modeled using dummy variables. For example, certain equations include dummy variables for some rate or classification changes that are inadequately modeled by the price indices used here. Dummy variables of this type are special cases of the non-linear intervention analysis outlined above.

## 6. Seasonality

Postal Calendar

The volume data used in modeling the demand for mail are quarterly. Before 2004, the Postal Service reported data using a 52-week Postal calendar composed of thirteen 28-day accounting periods.[3] Because the 52-week Postal year was only 364 days long, the beginning of the Postal year, as well as the beginning of each Postal quarter, shifted over time relative to the traditional Gregorian calendar. Specifically, the Postal calendar lost five days every four years relative to the Gregorian calendar. This created some unique difficulties in modeling the seasonality of mail volumes.

For example, prior to 1983, Christmas Day fell in the first quarter of the Postal year (which began in the previous Fall). After 1983, however, Christmas Day fell within the second Postal quarter. Between Postal Fiscal Year 1983 (PFY 1983) and PFY 1999 (the last year for which Postal quarterly data are used here), the second Postal quarter gained the 20 days immediately preceding Christmas (December 5 through December 24) which are among the Postal Service's heaviest days in terms of mail volume. Not surprisingly, therefore, the relative volumes of mail in Postal Quarter 1 and Postal Quarter 2 changed over this time period for most mail categories, as Christmas-related mailings shifted from the first Postal quarter to the second Postal quarter, solely because of the effect of the Postal Service's moving calendar.

This shift created a difficulty in modeling the seasonal pattern of mail volume using traditional econometric techniques, such as quarterly dummy variables. If the seasonal pattern of mail volume was due to seasonal variations within the Gregorian calendar (e.g., Christmas), then the perceived seasonal pattern across Postal quarters may not

[3] Postal Service volume data for Fiscal Years 2000 through 2003 were re-stated by Gregorian quarter at the time of this change in the Postal Service's calendar. These re-stated data are used here to estimate the Postal Service's demand equations.

have been constant over time, even if the true seasonal pattern across periods of the Gregorian calendar was constant over time.

Seasonal Variables, pre-2000

For demand equations whose sample period begins before 2000Q1, the seasonal variables included in the Postal Service's econometric demand equations are tied to the Gregorian calendar. This means that they vary over the Postal calendar prior to 2000. For demand equations whose sample period begins in 2000Q1 or later, Postal quarters line up perfectly with the Gregorian calendar over the full sample period. In these cases, the Postal Service's econometric demand equations include quarterly dummy variables to model seasonality. Even in these latter cases, however, the impact of Saturdays and Sundays is modeled empirically (in fact, it is only the time period since 2000Q1 where the number of Saturdays and Sundays within a particular quarter vary over time).

In the past, the seasonal variables used to model seasonality prior to 2000Q1 were discrete seasonal variables which measured the share of the relevant Postal quarter which fell within a particular Gregorian time period. Recently, these have been changed to a series of variables which allow for smoother seasonal transitions over time.

There are 12 seasonal variables, tied to 12 "target dates": specifically, the 15$^{th}$ of each month. Daily values associated with each of these variables are calculated such that any given date has non-zero values for the 2 "target dates" closest to it such that the sum of the two values associated with a particular date is equal to one and the weight on a particular date decreases as one gets farther away from it and increases as it gets closer to the target date.

Consider the example of the time period between November 15$^{th}$ and December 15$^{th}$. The two "target dates" associated with these dates are November 15$^{th}$ (Nov15) and December 15$^{th}$ (Dec15).

For November 15th, the value of Nov15 is set equal to 1; the value of Dec15 is set equal to zero. There are 30 days between November 15 and December 15. Hence, the values associated with Nov15 and Dec15 change by (1/30) per day over this time period.

For November 16th, the value of Nov15 is set equal to 29/30 (1 – 1/30), and the value of Dec15 is set equal to 1/30 (0 + 1/30).

For November 17th, the value of Nov15 is set equal to 28/30 (29/30 – 1/30), and the value of Dec15 is set equal to 2/30.

…

For December 14th, the value of Nov15 is set equal to 1/30, and the value of Dec15 is set equal to 29/30.

For December 15th, the value of Nov15 is set equal to zero and the value of Dec15 is set equal to one.

The value of, say, Nov15, for a particular quarter is then simply equal to the average daily value of Nov15 for the dates with the quarter of interest. For these calculations, all days are treated equally (i.e., no adjustments are made for Saturdays, Sundays, or Postal holidays). Because of this, the values of these variables are constant within a particular Postal quarter since 2000[4]. For example, the value of Nov15 is equal to 0.3315 in every Postal Quarter 1, while the value of Dec15 is equal to 0.2947 in every Postal Quarter 1 (and 0.0372 in every Postal Quarter 2, since the time period from Jan. 1 – Jan. 14 is between the target dates of December 15 and January 15).

In addition to these twelve seasonal variables, a thirteenth variable is created called CHRISTMAS. This variable is keyed to a single date as above: December 22nd, but only operates in the three weeks before this date, with the variable having a value (1/21) less than the next day (i.e., December 22 = 1, December 21 = (20/21), December 20 = (19/21), …, December 2 = (1/21), all other dates = 0). As with the monthly variables

[4] except for the Feb15 and Mar15 variables which vary slightly in Leap Years

above, all days are treated equally in calculating CHRISTMAS, so that it has a constant value in Postal Quarter 1 since 2000 (11/92 = 0.1196).

Adjoining seasons for which the coefficients are similar in sign and magnitude are combined in some cases.[5] These constraints across seasons are made on an equation-by-equation basis. The criterion used for this constraining process is generally to minimize the mean-squared error of the Equation which is equal to the sum of squared residuals divided by degrees of freedom).

### Changes to Seasonal Pattern over Time

In some cases, the seasonal pattern of certain mail categories appears to have changed somewhat over time. In these cases, additional or alternate seasonal variables may be introduced into the equation over sub-samples of the relevant sample period. In most cases, these take the form of quarterly dummies which start at some time after 2000. For example, the First-Class single-piece letters, cards, and flats equation includes a dummy variable equal to one in the first Postal quarter starting in 2008Q1; the Standard Regular Mail demand equation includes dummy variables equal to one in the second and third Postal quarter, respectively, starting in 2006.

In some cases, where the seasonal pattern of mail appears to be changing more gradually over time, one or more seasonal variables may be interacted with a time trend over some time period.

### Impact of Federal Election Cycle

One fairly significant use for the mail is for pre-election advertising by candidates, political parties, and special interest groups. Because of this, volumes for several

[5] Combined seasonals were given names which should be obvious in the econometric output. For example, when MAR15S and APR15S were combined, the combined variable was called MAR_APR15S.

categories of mail fluctuate with the election cycle, most notably with the Federal election cycle of every two (Congressional) or four (Presidential) years.

Dummy variables equal to one during specific quarters within Federal election years are included in several of the Postal Service's demand equations, most notably in the Standard Nonprofit and Standard Nonprofit ECR demand equations. These variables are typically included with the "Seasonal Variables" in the Postal Service's econometric output, and are included as part of the Seasonal Multiplier in the Postal Service's volume forecasting spreadsheet.

Seasonal Index

The estimated effects of the seasonal variables are combined into a seasonal index by multiplying each of the seasonal coefficients by the relevant seasonal variable and summing across all of the seasonal variables.

This seasonal index can be arrayed by Postal quarter to observe the quarterly seasonal pattern and to understand how this seasonal pattern changed over time prior to 2000 as a result of the moving Postal calendar. Since 2000, this seasonal index is generally constant for a given quarter each year, although changes in the number of Sundays within a given quarter and the existence of Leap Years lead to some modest year-to-year changes.

The seasonal coefficients and seasonal index for First-Class Letters, Cards, and Flats are shown next as an example.

Seasonal Variables

| | Coefficients | Std. Error | T-Ratio |
|---|---|---|---|
| JAN15S | -2.016482 | 0.668111 | -3.018185 |
| FEB15S | -0.068018 | 0.384008 | -0.177127 |
| MAR_MAY15S | -1.024928 | 0.494603 | -2.072224 |
| JUN15S | -0.699118 | 0.372999 | -1.874315 |
| JUL15S | -2.416059 | 1.104279 | -2.187906 |
| SEP15S | -1.007503 | 0.458287 | -2.198408 |
| OCT15S | -0.662388 | 0.658506 | -1.005895 |
| NOV15S | -1.406294 | 0.556132 | -2.528703 |
| DEC15S | -0.326860 | 0.445780 | -0.733230 |
| D_FS_Q1 | 0.041893 | 0.008517 | 4.918962 |

SEASONAL INDEX

| | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| 1983 | 0.093825 | -0.005620 | -0.010891 | -0.077021 |
| 1984 | 0.093753 | 0.002546 | -0.017272 | -0.075525 |
| 1985 | 0.091252 | 0.003738 | -0.020275 | -0.074764 |
| 1986 | 0.088822 | 0.008156 | -0.023153 | -0.073994 |
| 1987 | 0.085607 | 0.012815 | -0.025499 | -0.073214 |
| 1988 | 0.081606 | 0.022275 | -0.028678 | -0.071630 |
| 1989 | 0.071247 | 0.028244 | -0.029344 | -0.070824 |
| 1990 | 0.064888 | 0.033872 | -0.029562 | -0.070010 |
| 1991 | 0.057744 | 0.039741 | -0.029248 | -0.069186 |
| 1992 | 0.050891 | 0.047721 | -0.027529 | -0.067513 |
| 1993 | 0.038060 | 0.052337 | -0.025114 | -0.066663 |
| 1994 | 0.032081 | 0.054866 | -0.022672 | -0.065804 |
| 1995 | 0.026394 | 0.056559 | -0.019698 | -0.064936 |
| 1996 | 0.020998 | 0.059101 | -0.013431 | -0.063567 |
| 1997 | 0.011604 | 0.056628 | -0.007585 | -0.063458 |
| 1998 | 0.008130 | 0.054980 | -0.002483 | -0.063734 |
| 1999 | 0.005472 | 0.052498 | 0.003151 | -0.064393 |
| 2000 | 0.082293 | -0.003340 | -0.019288 | -0.076886 |
| 2001 | 0.082293 | -0.008084 | -0.019288 | -0.076886 |
| 2002 | 0.082293 | -0.008084 | -0.019288 | -0.076886 |
| 2003 | 0.082293 | -0.008084 | -0.019288 | -0.076886 |
| 2004 | 0.082293 | -0.003340 | -0.019288 | -0.076886 |
| 2005 | 0.082293 | -0.008084 | -0.019288 | -0.076886 |
| 2006 | 0.082293 | -0.008084 | -0.019288 | -0.076886 |
| 2007 | 0.082293 | -0.008084 | -0.019288 | -0.076886 |
| 2008 | 0.124186 | -0.003340 | -0.019288 | -0.076886 |
| 2009 | 0.124186 | -0.008084 | -0.019288 | -0.076886 |
| 2010 | 0.124186 | -0.008084 | -0.019288 | -0.076886 |
| 2011 | 0.124186 | -0.008084 | -0.019288 | -0.076886 |
| 2012 | 0.124186 | -0.003340 | -0.019288 | -0.076886 |
| 2013 | 0.124186 | -0.008084 | -0.019288 | -0.076886 |
| 2014 | 0.124186 | -0.008084 | -0.019288 | -0.076886 |
| 2015 | 0.124186 | -0.008084 | -0.019288 | -0.076886 |

**First-Class Mail**

First-Class Mail is a heterogeneous class of mail. First-Class Mail includes a wide variety of mail sent by a wide variety of mailers for a wide variety of purposes. This mail can be divided into various substreams of mail based on several possible criteria, including the content of the mail-piece (e.g., bills, statements, advertising, and personal correspondence), the sender of the mail-piece (e.g., households versus businesses versus government), or the recipient of the mail-piece (e.g., households versus business versus government).

First-Class Mail can be broadly divided into two categories of mail: Individual Correspondence, consisting of household-generated mail and non-household-generated mail sent a few pieces at a time; and Bulk Transactions, consisting of non-household-generated mail sent in bulk. Relating these two categories of First-Class Mail to rate categories, Individual Correspondence mail may be thought of as being approximately equivalent to First-Class Single-Piece Mail, while Bulk Transactions mail could be viewed as comparable to First-Class Workshared Mail. Of course, these equivalences are only approximate.

For econometric estimation purposes, domestic First-Class Mail is divided into seven mail categories: First-Class Single-Piece letters; First-Class Single-Piece cards; First-Class Single-Piece flats; First-Class Workshared letters; First-Class Workshared cards; First-Class Workshared flats; and First-Class Parcels. In addition, a separate demand equation is estimated for First-Class International letters, cards, and flats.

## First-Class Single-Piece Letters, Cards, and Flats Trunk Equation

For First-Class Single-Piece Letters, Cards, and Flats, a single "trunk equation" is estimated first. Individual equations are then estimated independently by shape, which incorporate stochastic restrictions from this "trunk equation" in order to ensure the reasonableness of the results from the individual equations. For more discussion of the "trunk equation" approach, please see the Response of the United States Postal Service to Notice of Inquiry No. 1, Docket No. RM2014-5 (August 28, 2015).

The trunk equation is not used directly in forecasting. Rather, the results associated with employment and postage price from the trunk equation are used as (stochastic) constraints in the individual demand equations.

### 1. Explanatory Variables used in First-Class Single-Piece Letters, Cards, and Flats Trunk Equation

The First-Class Single-Piece letters, cards, and flats trunk equation models First-Class Single-Piece mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Single-Piece letters, cards, and flats, and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Single-Piece letters, cards, and flats equation.

Employment was chosen as the macro-economic variable to be included in the First-Class Single-Piece trunk equation on the basis of a comparison of econometric results including several candidate macro-economic variables, including retail sales, consumption, and GDP. The theoretical rationale for including total employment as a macro-economic variable is that in many cases, mail volume is not affected by the dollar

value of economic transactions, so much as by the number of such transactions. For example, the number of credit card bill payments one makes does not necessarily go up as the total amount charged per card goes up. While variables like GDP or retail sales may be good measures of the total dollar amount of economic activity (e.g., the total amount charged per credit card), employment appears to be a better measure of the number of business transactions (e.g., number of bills paid).

Employment is entered into the First-Class Single-Piece Letters, Cards, and Flats equation lagged one quarter.

**(2) Postal Prices**

The First-Class Single-Piece letters, cards, and flats trunk equation includes a price index measuring the average price of First-Class Single-Piece letters, cards, and flats (PX01SP_LCF). The price variable is entered current and lagged up to four quarters.

**(3) Trends**

The First-Class Single-Piece letters, cards, and flats trunk equation includes linear time trends starting at four separate times: 1993Q4, 2003Q1, 2010Q2, and 2012Q4.[6]

The first two of these trends largely reflect changes in the impact of new mail-diverting technologies which were emerging and being rapidly adopted by businesses and households during these time periods. These trends may also reflect some shifts of mail from single-piece to workshared.

In the 1990s, these technologies were fax, e-mail, and electronic funds transfer (EFT). In the early 2000s, high-speed broadband Internet was becoming more widely adopted, and e-mail use began reaching wider audiences. Paying bills online became

[6] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

much more common. While all of these technologies existed in limited form for many years, their adoption accelerated over the time periods identified by these trends.

Given the nature of these trend variables, it is also likely that the changes in the rate of net mail diversion at these particular times were due to changes in other underlying trends that might have affected mail volume (some positive, some negative) that may have been unrelated to the Internet or electronic diversion rates. Trends within industries which are particularly heavy users of mail – e.g., banking, advertising, housing – are likely to be picked up by these trends in the same way that more recent trends in these industries caused by the Great Recession are explained by the more recent net mail trends that coincided with the Great Recession.

The trends starting in 2010Q2 and 2012Q4 capture a combination of trends associated with the Great Recession as well as increased technological diversion over this time period. The former of these includes, for example, declines in home ownership and a slowdown in the rate of household formation due to the Great Recession. In addition, mail volume is likely to have been adversely affected by the decline in median household income which continued even after the recession had officially ended in 2009. Along with the lingering economic impacts of the Great Recession captured in the 2010Q2 trend, the 2012Q4 trend reflects increased electronic diversion, perhaps as a result of the cost pressures brought on by the recession, or as a result of increased use of new technologies such as smartphones and social media to the limited extent such usage actually replaced former physical correspondence or transactions.

**(4) Non-Linear Intervention Variable**

The First-Class Single-Piece letters, cards, and flats trunk equation includes a non-linear intervention variable that starts in 2007Q4 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2007Q4 and 0 otherwise; $S_t = 1$ if t >2007Q4 and 0 otherwise. This variable has an initial value in 2007Q4 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

This variable is included to capture longer-lasting volume declines associated with the Great Recession, related to, for example, reductions in consumers' use of credit cards.

**(5) Other Variables**

The First-Class Single-Piece Letters, Cards, and Flats trunk equation includes four dummy Variable: D_R90, which is equal to one since the implementation of R90-1 rates in February, 1991, zero prior to that; MC95, which is equal to one since the implementation of classification reform (MC95-1) in July, 1996; D2002Q1, which is equal to 1 in 2002Q1, and R2006PHOP, which is equal to -1 in 2006Q1 and +1 in 2006Q2 and is related to the Postal Service's measure of Postage in the Hands of the Public (PHOP) just before and after the implementation of R2005-1 rates in January, 2006.

Finally, the First-Class Single-Piece Letters, Cards, and Flats trunk equation includes a set of seasonal variables including a quarterly dummy variable, D_FS_Q1, which is equal to 1 in quarter 1 since the introduction of Forever Stamps in 2007Q3.

## 2. Econometric Demand Equation: First-Class Single-Piece Letters, Cards, and Flats Trunk Equation

The effect of these variables on First-Class single-piece letters, cards, and flats volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class Single-Piece Letters, Cards, & Flats
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 30695.700 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 2.51% | -0.150 | -0.37% |
| EMPLOY(-1) | 4.12% | 0.549 | 2.24% |
| D_R90 | 0.00% | -0.039 | 0.00% |
| MC95 | 0.00% | 0.045 | 0.00% |
| D2002Q1 | 0.00% | -0.045 | 0.00% |
| R2006PHOP | 0.00% | -0.024 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2007Q4 | | | -0.63% |
| 1993Q4 | | | -17.09% |
| 2010Q2 | | | -24.70% |
| 2012Q4 | | | 14.45% |
| 2003Q1 | | | -7.08% |
| Seasonality | | | -0.18% |
| Other Factors | | | -0.69% |
| Mechanical Net Trend | | | 0.998621 |
| Base Volume | | | 21674.120 |
| Total Change in Volume | | | -29.39% |

## First-Class Single-Piece Letters

The First Class Single-Piece Letters demand equation is estimated using stochastic constraints on the coefficients on employment and postage price, obtained from the First-Class Single-Piece Letters, Cards, and Flats Trunk Equation.

The First-Class Single-Piece Letters equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in First-Class Single-Piece Letters Equation

The First-Class Single-Piece Letters demand equation models First-Class Single-Piece letters volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Single-Piece Letters and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Single-Piece Letters equation.

Employment is entered into the First-Class Single-Piece Letters equation lagged one quarter.

**(2) Postal Prices**

The First-Class Single-Piece Letters equation includes a price index measuring the average price of First-Class Single-Piece Letters (PX01SP_L). The price variable is entered current and lagged up to four quarters.

**(3) Trends**

The First-Class Single-Piece Letters demand equation includes linear time trends starting at three separate times: 2004Q1, 2010Q2, and 2012Q4.[7]

**(4) Non-Linear Intervention Variable**

The First-Class Single-Piece letters demand equation includes a non-linear intervention variable that starts in 2008Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q1 and 0 otherwise; $S_t = 1$ if t >2008Q1 and 0 otherwise. This variable has an initial value in 2008Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

This variable is included to capture longer-lasting volume declines associated with the Great Recession, related to, for example, reductions in consumers' use of credit cards.

[7] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

### (5) Other Variables

The First-Class Single-Piece Letters equation includes one dummy variable: R2006PHOP, which is equal to -1 in 2006Q1 and +1 in 2006Q2 and is related to the Postal Service's measure of Postage in the Hands of the Public (PHOP) just before and after the implementation of R2005-1 rates in January, 2006.

Finally, the First-Class Single-Piece Letters equation includes a set of seasonal variables including a quarterly dummy, D_FS_Q1, which is equal to 1 in quarter 1 since the introduction of Forever Stamps in 2007Q3.

## 2. Econometric Demand Equation: First-Class Single-Piece Letters

The effect of these variables on First-Class single-piece letters volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class Single-Piece Letters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 27437.340 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 1.61% | -0.101 | -0.16% |
| EMPLOY(-1) | 4.12% | 0.542 | 2.21% |
| R2006PHOP | 0.00% | -0.033 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q1 | | | -0.01% |
| 2004Q1 | | | -23.59% |
| 2010Q2 | | | -24.01% |
| 2012Q4 | | | 15.91% |
| Seasonality | | | -0.20% |
| Other Factors | | | -0.81% |
| Mechanical Net Trend | | | 0.998372 |
| Base Volume | | | 19768.113 |
| Total Change in Volume | | | -27.95% |

## First-Class Single-Piece Cards

The First Class Single-Piece Cards demand equation is estimated using stochastic constraints on employment and postage price, obtained from the First-Class Single-Piece Letters, Cards, and Flats Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in First-Class Single-Piece Cards Equation

The First-Class Single-Piece Cards demand equation models First-Class Single-Piece Cards volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Single-Piece Cards and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Single-Piece Cards equation.

Employment is entered into the First-Class Single-Piece Cards equation lagged one quarter.

**(2) Postal Prices**

The First-Class Single-Piece Cards equation includes a price index measuring the average price of First-Class Single-Piece cards (PX01SP_C). The price variable is entered current and lagged up to four quarters.

**(3) Trends**

The First-Class Single-Piece Cards demand equation includes linear time trends starting at two separate times: 2004Q1 and 2010Q2.[8]

**(4) Non-Linear Intervention Variable**

The First-Class Single-Piece cards demand equation includes a non-linear intervention variable that starts in 2008Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q1 and 0 otherwise; $S_t = 1$ if t >2008Q1 and 0 otherwise. This variable has an initial value in 2008Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

This variable is included to capture longer-lasting volume declines associated with the Great Recession.

**(5) Other Variables**

The First-Class Single-Piece Cards equation includes two dummy Variable: R2006PHOP, which is equal to -1 in 2006Q1 and +1 in 2006Q2 and is related to the Postal Service's measure of Postage in the Hands of the Public (PHOP) just before and

[8] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

after the implementation of R2005-1 rates in January, 2006; and D_R07, which is equal to one since the implementation of R2006-1 rates in May, 2007, zero earlier.

Finally, the First-Class Single-Piece Cards equation includes a set of seasonal variables including a quarterly dummy, D_FS_Q1, which is equal to 1 in quarter 1 since the introduction of Forever Stamps in 2007Q3.

## 2. Econometric Demand Equation: First-Class Single-Piece Cards

The effect of these variables on First-Class single-piece cards volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Single-Piece First-Class Cards
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 1447.435 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 10.88% | -0.221 | -2.26% |
| EMPLOY(-1) | 4.12% | 0.545 | 2.23% |
| R2006PHOP | 0.00% | -0.027 | 0.00% |
| D_R07 | 0.00% | -0.067 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q1 | | | -0.01% |
| 2004Q1 | | | -29.17% |
| 2010Q2 | | | -22.64% |
| Seasonality | | | -0.01% |
| Other Factors | | | 0.50% |
| Mechanical Net Trend | | | 1.001005 |
| Base Volume | | | 843.965 |
| Total Change in Volume | | | -41.69% |

## First-Class Single-Piece Flats

The First Class Single-Piece Flats demand equation is estimated using stochastic constraints on employment and postage price, obtained from the First-Class Single-Piece Letters, Cards, and Flats Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in First-Class Single-Piece Flats Equation

The First-Class Single-Piece Flats demand equation models First-Class Single-Piece Flats volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Single-Piece Flats and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Single-Piece Flats equation.

Employment is entered into the First-Class Single-Piece Flats equation lagged four quarters.

**(2) Postal Prices**

The First-Class Single-Piece Flats equation includes a price index measuring the average price of First-Class Single-Piece Flats (PX01SP_F). The price variable is entered current and lagged up to four quarters.

**(3) Trends**

The First-Class Single-Piece Flats demand equation includes a linear time trend starting in 2004Q1.[9]

**(4) Non-Linear Intervention Variable**

The First-Class Single-Piece Flats demand equation includes a non-linear intervention variable that starts in 2008Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q1 and 0 otherwise; $S_t = 1$ if t >2008Q1 and 0 otherwise. This variable has an initial value in 2008Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

This variable is included to capture longer-lasting volume declines associated with the Great Recession.

[9] This trend appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

### (5) Other Variables

The First-Class Single-Piece Flats equation includes one dummy variable: D_R07, which is equal to one since the implementation of R2006-1 rates in May, 2007, zero earlier.

Finally, the First-Class Single-Piece Flats equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Flats

The effect of these variables on First-Class single-piece flats volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class Single-Piece Flats
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 1810.925 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 5.88% | -0.120 | -0.68% |
| EMPLOY(-4) | -0.13% | 0.522 | -0.07% |
| D_R07 | 0.00% | -0.078 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q1 | | | -24.21% |
| 2004Q1 | | | -26.70% |
| Seasonality | | | -0.13% |
| Other Factors | | | 0.48% |
| Mechanical Net Trend | | | 1.000954 |
| Base Volume | | | 1062.042 |
| Total Change in Volume | | | -41.35% |

## First-Class Single-Piece Parcels

The First Class Single-Piece Parcels demand equation is estimated using stochastic constraints on e-commerce sales and price obtained from the Shipping and Package Services Trunk Equation. This trunk equation is described in the document "Narrative Explanation of Econometric Demand Equations for Competitive Products Filed with Postal Regulatory Commission on January 20, 2016", which was filed non-publically concurrent with this document.

### 1. Explanatory Variables used in First-Class Single-Piece Parcels Equation

The First-Class single-piece parcels demand equation includes the following explanatory variables.

#### (1) Macro-Economic Variable: E-Commerce

First-Class Single-Piece Parcels consist largely of the delivery of products bought by the sender or recipient of the mail. In both cases, these types of mail volume can be thought of as deriving almost directly from either expected or actual retail sales. Online shopping (referred to as e-commerce) is growing and resulting in more packages being delivered to households and businesses. More specifically, First-Class Single-Piece Parcels are a function of online retail sales, that is, sales of goods which are delivered to the consumer. Hence, private e-commerce sales per adult (ECOMM) is included directly in the demand equation for First-Class Single-Piece Parcels to reflect this direct relationship between mail-order retail sales and this mail volume.

### (2) Time Trends

The First-Class single-piece parcels equation includes a full-sample linear time trend, TREND.

### (3) Postal Prices

The First-Class single-piece equation includes a price index measuring the average price of First-Class single-piece parcels (PX01SP_P). The price variable is entered current and lagged up to four quarters.

### (4) Other Variables

The First-Class single-piece parcels equation includes one dummy variable, D2014Q2 which is equal to 1 in 2014Q2.

The First-Class single-piece parcels equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Single-Piece Parcels

The effect of these variables on First-Class Single-Piece Parcels volume over the past two years (2014 and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class Retail Parcels
VOLUME OVER LAST TWO YEARS

| | | | |
|---|---|---|---|
| Volume 2 Years Ago | | | 242.467 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| ECOMM | 25.27% | 0.477 | 11.34% |
| TREND | 297995.80% | -0.033 | -22.98% |
| D2014Q2 | 0.00% | 0.061 | 0.00% |
| PX01SP_P | 14.21% | -0.473 | -6.09% |
| Adult Population | | | 2.31% |
| Seasonality | | | -2.38% |
| Other Factors | | | 2.74% |
| Mechanical Net Trend | | | 1.009063 |
| Base Volume | | | 200.346 |
| Total Change in Volume | | | -17.37% |

## First-Class Workshared Letters, Cards, and Flats Trunk Equation

For First-Class Workshared Letters, Cards, and Flats, a single "trunk equation" is estimated first. Individual equations are then estimated independently by shape, which incorporate stochastic restrictions from this "trunk equation" in order to ensure the reasonableness of the results from the individual equations.

The trunk equation is not used directly in forecasting. Rather, the results associated with employment and postage price from the trunk equation are used as (stochastic) constraints in the individual demand equations.

### 1. Explanatory Variables used in First-Class Workshared Letters, Cards, and Flats Trunk Equation

The First-Class workshared letters, cards, and flats trunk equation models First-Class workshared mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Workshared letters, cards, and flats and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Workshared letters, cards, and flats trunk Equation.

Employment was chosen as the macro-economic variable to be included in the First-Class Workshared Mail trunk equation on the basis of a comparison of econometric results including several candidate macro-economic variables, including retail sales, consumption, and GDP. The theoretical rationale for including total employment as a macro-economic variable is that in many cases, mail volume is not affected by the dollar value of economic transactions, so much as by the number of such transactions. For example, the number of credit card bills one receives does not necessarily go up as the

total amount charged per card goes up. While variables like GDP or retail sales may be good measures of the total dollar amount of economic activity (e.g., the total amount charged per credit card), employment appears to be a better measure of the number of business transactions (e.g., number of bills received).

Employment per adult is entered into the First-Class Workshared letters, cards, and flats trunk equation lagged one quarter.

**(2) Postal Prices**

The First-Class Workshared letters, cards, and flats trunk equation includes a single Postal price: the price of First-Class Workshared letters, cards, and flats (PX1WS_LCF). The price variable is entered current and lagged up to four quarters.

**(3) Logistic Time Trend**

The First-Class Workshared letters, cards, and flats trunk equation includes a logistic time trend starting in 1992Q1, (@LOG(TREND-84)).

This time trend is included in the First-Class Workshared letters, cards, and flats, trunk equation to model positive factors which contributed to First-Class Workshared mail volume growth through the 1990s and into the 2000s. These factors included migration of mail from Single-Piece to Workshared mail, positive trends in direct-mail advertising, and increasing numbers of financial transactions. This time trend is logistic, which means that it is increasing at a decreasing rate, to reflect the diminishing positive influence of these factors (particularly shifts of mail from Single-Piece to Workshared) over time.

**(4) Linear Trends**

The First-Class Workshared letters, cards, and flats trunk equation includes linear time trends starting at four separate times: 2002Q3, 2004Q1, 2010Q4, and 2014Q1.[10]

The first two of these trends reflect changes in the impact of Internet and electronic diversion on First-Class Workshared Mail as well as changes in other underlying trends that might have affected mail volume (some positive, some negative) over these time periods.

The trends starting in 2010Q2 and 2014Q1 capture a combination of trends associated with the Great Recession as well as increased technological diversion over this time period. The former of these includes, for example, declines in home ownership and a slowdown in the rate of household formation due to the Great Recession. In addition, mail volume is likely to have been adversely affected by the decline in median household income which continued even after the recession had officially ended in 2009. Along with the lingering economic impacts of the Great Recession captured in the 2010Q2 trend, the 2014Q1 trend reflects increased electronic diversion, perhaps as a result of the cost pressures brought on by the recession, or as a result of increased use of new technologies such as smartphones and social media to the limited extent such usage actually replaced former physical correspondence or transactions.

**(5) Non-Linear Intervention Variable**

The First-Class Workshared letters, cards, and flats demand equation includes a non-linear intervention variable that starts in 2008Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

[10] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q1 and 0 otherwise; $S_t = 1$ if t >2008Q1 and 0 otherwise. This variable has an initial value in 2008Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

This variable is included to capture longer-lasting volume declines associated with the Great Recession, related to, for example, reductions in consumers' use of credit cards.

### (6) Other Variables

The First-Class Workshared Letters, Cards, and Flats equation includes one dummy variable: MC95, which is equal to one since the implementation of MC95-1 classification reform in 1996Q4.

Finally, the First-Class Workshared Letters, Cards, and Flats equation includes a set of seasonal variables. This includes a dummy variable, D_EL1, which is equal to one in the first Postal quarter of Federal election years[11] to capture election-generated mail volume such as voter registration cards and candidate literature and a seasonal variable.

[11] The first Postal quarter occurs in the fall preceding the calendar year of the same number, so, for example, 2013Q1 will begin on October 1, 2012. Hence, "the first quarter of Federal election years" refers to the fall (Oct – Dec) of odd-numbered Postal Fiscal Years.

## 2. Econometric Demand Equation: First-Class Workshared Letters, Cards, and Flats Trunk Equation

The effect of these variables on First-Class workshared letters, cards, and flats volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class Workshared Letters, Cards, & Flats
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 46895.948 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 5.11% | -0.320 | -1.58% |
| EMPLOY(-1) | 4.12% | 0.437 | 1.78% |
| @LOG(TREND-84) | 26.85% | 0.206 | 5.02% |
| MC95 | 0.00% | -0.109 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q1 | | | -4.86% |
| 2002Q3 | | | -11.83% |
| 2010Q4 | | | -17.67% |
| 2014Q1 | | | 4.43% |
| 2004Q1 | | | 8.23% |
| Seasonality | | | 0.09% |
| Other Factors | | | -0.16% |
| Mechanical Net Trend | | | 0.999679 |
| Base Volume | | | 40785.731 |
| Total Change in Volume | | | -13.03% |

## First-Class Workshared Letters

The First Class Workshared Letters demand equation is estimated using stochastic constraints on employment and postage price, obtained from the First-Class Workshared Letters, Cards, and Flats Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in First-Class Workshared Letters Equation

The First-Class workshared Letters demand equation models First-Class workshared mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Workshared Letters and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Workshared Letters Trunk Equation.

Employment per adult is entered into the First-Class Workshared Letters equation lagged one quarter.

**(2) Postal Prices**

The First-Class Workshared Letters Trunk Equation includes a single Postal price: the price of First-Class Workshared letters (PX01WS_L). The price variable is entered current and lagged up to four quarters.

**(3) Linear Trends**

The First-Class Workshared Letters demand equation includes linear time trends starting at three separate times: 2004Q1, 2010Q4, and 2014Q1.[12]

The first two of these trends reflect changes in the impact of Internet and electronic diversion on First-Class Workshared Mail as well as changes in other underlying trends that might have affected mail volume (some positive, some negative) over these time periods.

The trends starting in 2010Q2 and 2014Q1 capture a combination of trends associated with the Great Recession as well as increased technological diversion over this time period. The former of these includes, for example, declines in home ownership and a slowdown in the rate of household formation due to the Great Recession. In addition, mail volume is likely to have been adversely affected by the decline in median household income which continued even after the recession had officially ended in 2009. Along with the lingering economic impacts of the Great Recession captured in the 2010Q2 trend, the 2014Q1 trend reflects increased electronic diversion, perhaps as a result of the cost pressures brought on by the recession, or as a result of increased use of new technologies such as smartphones and social media to the limited extent such usage actually replaced former physical correspondence or transactions.

[12] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

### (4) Non-Linear Intervention Variable

The First-Class Workshared Letters demand equation includes a non-linear intervention variable that starts in 2008Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q1 and 0 otherwise; $S_t = 1$ if t >2008Q1 and 0 otherwise. This variable has an initial value in 2008Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

This variable is included to capture longer-lasting volume declines associated with the Great Recession, related to, for example, reductions in consumers' use of credit cards.

### (5) Other Variables

The First-Class Workshared Letters equation includes one dummy variable: D_R07, which is equal to one since the implementation of R2006-1 rates in May, 2007, zero earlier.

Finally, the First-Class Workshared Letters equation includes a set of seasonal variables. This includes a dummy variable, D_EL1, which is equal to one in the first Postal quarter of Federal election years[13] to capture election-generated mail volume such as voter registration cards and candidate literature and a seasonal variable, SAT_SUN, that is equal to the number of Saturdays and Sundays within a particular quarter.

[13] The first Postal quarter occurs in the fall preceding the calendar year of the same number, so, for example, 2013Q1 will begin on October 1, 2012. Hence, "the first quarter of Federal election years" refers to the fall (Oct – Dec) of odd-numbered Postal Fiscal Years.

## 2. Econometric Demand Equation: First-Class Workshared Letters

The effect of these variables on First-Class workshared letters volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class Workshared Letters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 43293.871 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 4.88% | -0.262 | -1.24% |
| EMPLOY(-1) | 4.12% | 0.372 | 1.51% |
| D_R07 | 0.00% | -0.009 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q1 | | | -7.95% |
| 2004Q1 | | | 2.07% |
| 2010Q4 | | | -15.04% |
| 2014Q1 | | | 3.39% |
| Seasonality | | | 0.17% |
| Other Factors | | | -0.08% |
| Mechanical Net Trend | | | 0.999849 |
| Base Volume | | | 38004.707 |
| Total Change in Volume | | | -12.22% |

## First-Class Workshared Cards

The First Class Workshared Cards demand equation is estimated using stochastic constraints on employment and postage price, obtained from the First-Class Workshared Letters, Cards, and Flats Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in First-Class Workshared Cards Equation

The First-Class Workshared Cards demand equation models First-Class Workshared Cards volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Workshared Cards and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Workshared Cards equation.

Employment per adult is entered into the First-Class Workshared Cards equation lagged one quarter.

**(2) Postal Prices**

The First-Class Workshared Cards equation includes a single Postal price: the price of First-Class Workshared cards (PX01WS_C). The price variable is entered current and lagged up to four quarters.

**(3) Linear Trends**

The First-Class Workshared cards demand equation includes linear time trends starting at two separate times: 2004Q1 and 2010Q4.[14]

The first of these trends reflects changes in the impact of Internet and electronic diversion on First-Class Workshared Mail as well as changes in other underlying trends that might have affected mail volume (some positive, some negative) over these time periods.

The final trend, which starts in 2010Q4, captures a combination of longer-run trends associated with the Great Recession as well as increased technological diversion over this time period.

**(4) Non-Linear Intervention Variable**

The First-Class Workshared cards demand equation includes a non-linear intervention variable that starts in 2008Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q1 and 0 otherwise; $S_t = 1$ if t >2008Q1 and 0 otherwise. This variable has an initial value in 2008Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

[14] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

This variable is included to capture longer-lasting volume declines associated with the Great Recession.

**(5) Other Variables**

The First-Class Workshared cards Trunk Equation includes a dummy variable, MC95, which is equal to one since the implementation of MC95-1 (classification reform) in 1996Q4.

Finally, the First-Class Workshared cards Trunk Equation includes a set of seasonal variables. This includes a dummy variable, D_EL1, which is equal to one in the first Postal quarter of Federal election years[15], to capture election-generated mail volume such as voter registration cards and candidate literature.

[15] The first Postal quarter occurs in the fall preceding the calendar year of the same number, so, for example, 2013Q1 will begin on October 1, 2012. Hence, "the first quarter of Federal election years" refers to the fall (Oct – Dec) of odd-numbered Postal Fiscal Years.

## 2. Econometric Demand Equation: First-Class Workshared Cards

The effect of these variables on First-Class workshared cards volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Workshared First-Class Cards
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 2931.565 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 11.78% | -0.166 | -1.83% |
| EMPLOY(-1) | 4.12% | 0.440 | 1.79% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q1 | | | -3.28% |
| 2004Q1 | | | 36.60% |
| 2010Q4 | | | -47.44% |
| Seasonality | | | 0.31% |
| Other Factors | | | 0.31% |
| Mechanical Net Trend | | | 1.000626 |
| Base Volume | | | 2169.537 |
| Total Change in Volume | | | -25.99% |

## First-Class Workshared Flats

### 1. Explanatory Variables used in First-Class Workshared Flats Equation

The First Class Workshared Flats demand equation is estimated using stochastic constraints on employment and postage price, obtained from the First-Class Workshared Letters, Cards, and Flats Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

#### (1) Macro-Economic Variable: Employment

The relationship between First-Class Workshared Flats and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the First-Class Workshared Flats equation.

Employment per adult is entered into the First-Class Workshared flats equation lagged one quarter.

**(2) Postal Prices**

The First-Class Workshared flats equation includes a single Postal price: the price of First-Class Workshared Flats (PX01WS_F). The price variable is entered current and lagged up to four quarters.

**(3) Linear Trends**

The First-Class Workshared flats demand equation includes a linear time trend starting at 2004Q1.[16]

The trend reflects changes in the impact of Internet and electronic diversion on First-Class Workshared Mail as well as changes in other underlying trends that might have affected mail volume (some positive, some negative) over this time.

**(4) Non-Linear Intervention Variable**

The First-Class Workshared flats demand equation includes a non-linear intervention variable that starts in 2008Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q1 and 0 otherwise; $S_t = 1$ if t >2008Q1 and 0 otherwise. This variable has an initial value in 2008Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

This variable is included to capture longer-lasting volume declines associated with the Great Recession, related to, for example, reductions in consumers' use of credit cards.

[16] This trend appears in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

### (5) Other Variables

The First-Class Workshared Flats equation includes one dummy variable: D_R07, which is equal to one since the implementation of R2006-1 rates in May, 2007, zero earlier.

Finally, the First-Class Workshared Flats equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class Workshared Flats

The effect of these variables on First-Class workshared flats volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class Workshared Flats
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 670.512 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 8.69% | -0.519 | -4.23% |
| EMPLOY(-1) | 4.12% | 0.402 | 1.64% |
| D_R07 | 0.00% | -0.164 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q1 | | | -28.46% |
| 2004Q1 | | | 24.41% |
| Seasonality | | | -0.03% |
| Other Factors | | | -0.65% |
| Mechanical Net Trend | | | 0.998695 |
| Base Volume | | | 611.488 |
| Total Change in Volume | | | -8.80% |

## First-Class International Letters, Cards, and Flats

### 1. Explanatory Variables used in First-Class International Letters, Cards, and Flats Trunk Equation

The First-Class International letters, cards, and flats demand equation models First-Class International letters, cards, and flats volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Exports

The relationship between First-Class International mail and the general economy is modeled through the inclusion of real exports per adult (XR) as an explanatory variable in the First-Class International letters, cards, and flats demand equation.

The theoretical rationale for including exports as a macro-economic variable is that it is a measure of international economic activity. Increased trade activity would be expected to result in an increase in the number of bills, other financial statements, and other business and personal communications that are mailed to foreign countries.

#### (2) Time Trend

The First-Class International letters, cards, and Flats Trunk Equation includes a full-sample linear time trend.

#### (3) Postal Prices

The First-Class International letters, cards, and Flats Trunk Equation includes a single Postal price: the price of First-Class International letters, cards, and flats (PX1I_LCF). The price variable is entered current and lagged up to four quarters.

### (4) Other Variables

The First-Class International Letters, Cards, and Flats equation includes dummy variables for 2009Q2, 2009Q3, and 2009Q4, and a dummy variable, D_R14, which is equal to one since the Postal Service's January, 2014, rate increase.

The First-Class International Letters, Cards, and Flats equation also includes a set of seasonal variables.

## 2. Econometric Demand Equation: First-Class International Letters, Cards, and Flats

The effect of these variables on First-Class International letters, cards, and flats volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
First-Class International Letters, Cards, & Flats
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 280.090

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| Own-Price | 24.40% | -0.101 | -2.18% |
| XR | 15.08% | 0.952 | 14.31% |
| TREND | 48516519440.9% | -0.031 | -46.45% |
| D2009Q2 | 0.00% | 0.341 | 0.00% |
| D2009Q3 | 0.00% | 0.611 | 0.00% |
| D2009Q4 | 0.00% | 0.653 | 0.00% |
| D_R14 | 171.83% | 0.181 | 19.87% |
| Adult Population | | | 5.99% |
| Seasonality | | | 0.41% |
| Other Factors | | | -0.82% |
| Mechanical Net Trend | | | 0.998346 |
| Base Volume | | | 212.184 |
| Total Change in Volume | | | -24.24% |

## Standard Mail

### 1. Overview of Direct-Mail Advertising

More than 90 percent of Standard Mail can be characterized as direct-mail advertising. Hence, understanding the demand for direct-mail advertising is the key to understanding the demand for Standard Mail volume.

The demand for Standard Mail volume is the result of a choice by advertisers regarding how much to spend on direct-mail advertising expenditures. The decision process made by direct-mail advertisers can be decomposed into two separate, but interrelated, decisions:

(1) How much to invest in advertising?

(2) Which advertising medium to use?

These two decisions are integrated into the demand equations associated with Standard Mail volume by including a set of explanatory variables in the demand equations for Standard Mail that addresses each of these decisions. These decisions, and their implications for Standard Mail equations, are considered separately below.

### 2. Advertising Decisions and Their Impact on Mail Volume

#### a. How Much to Invest in Advertising

Advertising can be thought of as a form of business investment – an expenditure made in the present for the purpose of increasing revenue in the future. Hence, the Standard Mail equations include real gross private domestic investment as a measure of the overall demand for business investment.

In addition to macroeconomic factors, the overall level of advertising is also affected by certain other regular events. In particular, in the United States, the election cycle is a key factor which drives advertising spending. In the case of Standard Mail, the election cycle is particularly important with respect to preferred-rate mail, i.e., Standard Nonprofit and Nonprofit Enhanced Carrier Route (ECR) mail. Variables which coincide with the

timing of Federal elections are included in the all of the Standard Mail demand equations which were filed with the Commission on January 20, 2016.

**b. Which Advertising Media to Use**

The choice of advertising media can be thought of as primarily a pricing decision, so that the primary determinant of the demand for direct-mail advertising (vis-à-vis other advertising media) would be the price of direct-mail advertising.

The most obvious way in which the price of direct-mail advertising is included in the Standard Mail equations is through the price of Standard Mail. Postage costs are included in the Standard Mail equations through fixed-weight price indices which measure the average postage paid by Standard Mailers.

One of the principal advantages of direct-mail advertising over other forms of advertising is that direct-mail advertising allows an advertiser to address customers on a one-on-one basis. By identifying specifically who will receive a particular piece of direct-mail advertising, direct-mail advertising is able to provide an inherent level of targeting that is not necessarily available through other advertising media.

The ability to target a direct mailing to specific individuals, based on specific advertiser-chosen criteria, increased dramatically as a result of technological advances over the past twenty to thirty years. The ease with which one is able to identify specific consumers or businesses at whom to target direct-mail advertising is a key component of the cost of direct-mail advertising. A linear time trend is included in the Standard Regular equation. This time trend has a positive coefficient through most of the sample period used here, reflecting this positive influence of targeting.

More recent changes to the overall advertising market, as well as direct mail's role within that market, are modeled via Intervention analysis. The general concept of Intervention analysis was described earlier in this document. The specific demand

specifications associated with the demand equations developed here for Standard Mail are described below.

## Standard Regular Mail (excluding parcels) Trunk Equation

For Standard Regular Mail, a single "trunk equation" is estimated first. Individual equations are then estimated independently for Standard Regular Letters and Standard Regular Machineable Non-Letters which incorporate stochastic restrictions from this "trunk equation" in order to ensure the reasonableness of the results from the individual equations.

The trunk equation is not used directly in forecasting. Rather, the results associated with investment and postage price from the trunk equation are used as (stochastic) constraints in the individual demand equations.

### 1. Explanatory Variables used in Standard Regular Mail Equation

The Standard Regular Mail (excluding parcels) demand equation models Standard Regular mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Investment

The relationship between Standard Regular Mail (excluding parcels) volume and the economy is modeled through the inclusion of gross private domestic investment per adult (INVR).

#### (2) Impact of the Great Recession

The Great Recession hit advertising expenditures, and, hence, Standard mail volume, much harder than would have been expected, even given the decline that occurred in private investment. To capture this effect econometrically, an Intervention

variable is added to the Standard Regular Mail (excluding parcels) trunk equation that starts in 2008Q2 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q2 and 0 otherwise; $S_t = 1$ if t >2008Q2 and 0 otherwise. This variable has an initial value in 2008Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(3) Postal Prices**

The Standard Regular Mail (excluding parcels) trunk equation includes a price index measuring the average price of non-parcel Standard Regular mail (PX3R_NCR_NP). The price variable is entered current and lagged up to four quarters.

**(4) Time Trend**

The Standard Regular Mail (excluding parcels) trunk equation includes two linear trend variables: a full-sample linear trend and a second trend which is estimated starting in 2007Q2.[17]

The full-sample trend is included to capture general increases in the attractiveness of direct-mail advertising as a desirable advertising medium as well as in Standard Regular mail volume specifically relative to other direct-mail alternatives (e.g., Standard ECR mail). The second trend is introduced in 2007 due to weakness in the overall advertising industry (whose share of GDP declined considerably starting in 2007) as well as in specific industries which are heavy users of direct-mail advertising (e.g., the

[17] This trend appears in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

financial industry) due to the factors which ultimately led to the Great Recession (e.g., housing prices peaked in 2006).

**(5) Other Variables**

The Standard Regular Mail (excluding parcels) trunk equation includes several dummy and Intervention variables to reflect the impact of various one-time events and/or changes to the relative relationship between Standard Regular mail and other mail categories.

**(a) MC95-1**

A dummy variable (D1996Q4) equal to one in 1996Q4, zero elsewhere, and an Intervention variable starting in 1997Q1 are included in the Standard Regular Mail (excluding parcels) trunk equation to model the impact of classification reform (MC95-1), which was implemented in the middle of 1996Q4. These variables are included in the Standard Regular Mail (excluding parcels) trunk equation to reflect the impact of rule changes implemented at that time that are not fully captured by the Standard Regular Mail (excluding parcels) price index. The effect of these rule changes in modeled by an intervention variable instead of a dummy to better reflect the fact that the full impact of mailers to these changes was not necessarily immediate.

**(b) R97-1**

An Intervention variable starting in 1999Q3 is included in the Standard Regular mail equation to model the impact of R97-1 rates, which were implemented in 1999Q2. Standard ECR basic letter rates were set greater than Standard Regular automation 5-digit letter rates in the R97-1case, leading some mail to migrate from Standard ECR to Standard Regular. The effect of this rate crossover is modeled by an intervention variable instead of a dummy to better reflect the fact that it took some mailers time to

adjust their mailing practices to take advantage of the rate savings available to them from automating their mail.

**(c) 2002Q2**

A dummy variable, D2002Q2, is included in the Standard Regular equation, which is equal to one in 2002Q2, zero elsewhere. This represents the quarter immediately following a bio-terrorist Anthrax attack in the fall of 2001. This attack had a temporary negative impact on the level of direct-mail advertising in general and on Standard Regular mail volumes in particular.

**(d) R2006-1**

A dummy variable equal to one starting with the implementation of R2006-1 rates in 2007Q3 (D_R07) is included in the Standard Regular equation. Standard ECR automation letter discounts were eliminated at this time, leading this mail to migrate from Standard ECR to Standard Regular.

**(e) 2012**

A dummy variable, D2012Q1, equal to one in 2012Q1, zero otherwise, is included in the Standard Regular equation. Another dummy variable, D2012Q2ON, which is equal to one from 2012Q2 forward, is also included in the Standard Regular demand equation. These dummies are included to account for significant unexplained declines in Standard Regular mail volume in FY 2012 that appear to be permanent.

**(f) Election Dummies**

Political campaigns are heavy users of Standard mail volume. Because of the general timing of Federal elections in only even-numbered years, the effect of elections on Standard mail volumes is not adequately modeled by seasonal variables.

Two dummy variables are included in the Standard Regular Mail (excluding parcels) demand equation to model the impact of Federal elections on Standard Regular Mail volume: D_EL4_PRES, which is equal to one in the fourth Postal quarter of Presidential election years; and D_EL4_08, which is equal to one in the fourth Postal quarter of Federal election years since 2008.

### (g) Seasonal Variables

Finally, the Standard Regular Mail (excluding parcels) equation includes a set of seasonal variables.

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## 2. Econometric Demand Equation: Standard Regular Mail (excluding parcels) Trunk Equation

The effect of these variables on Standard Regular Mail (excluding parcels) volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Standard Regular (ex. Parcels)
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 44462.941 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 4.16% | -0.450 | -1.81% |
| INVR | 28.89% | 0.366 | 9.74% |
| TREND | 48516519440.9% | 0.007 | 14.53% |
| D1996Q4 | 0.00% | -0.059 | 0.00% |
| D2002Q2 | 0.00% | -0.062 | 0.00% |
| D_R07 | 0.00% | 0.039 | 0.00% |
| D2012Q1 | 0.00% | -0.076 | 0.00% |
| D2012Q2ON | 171.83% | -0.147 | -13.70% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q2 | | | -0.06% |
| 2007Q2 | | | -14.89% |
| 1997Q1 | | | 0.00% |
| 1999Q3 | | | 0.06% |
| Seasonality | | | 0.83% |
| Other Factors | | | -1.26% |
| Mechanical Net Trend | | | 0.997466 |
| Base Volume | | | 42525.763 |
| Total Change in Volume | | | -4.36% |

## Standard Regular Letters

The Standard Regular Letters demand equation is estimated using stochastic constraints on investment and postage price, obtained from the Standard Regular (excluding parcels) Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in Standard Regular Mail Equation

The Standard Regular Letters demand equation models Standard Regular Letters volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Investment

The relationship between Standard Regular Letters volume and the economy is modeled through the inclusion of gross private domestic investment per adult (INVR).

#### (2) Impact of the Great Recession

The Great Recession hit advertising expenditures, and, hence, Standard Regular Letters volume, much harder than would have been expected, even given the decline that occurred in private investment. To capture this effect econometrically, an Intervention variable is added to the Standard Regular demand equation that starts in 2008Q2 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q2 and 0 otherwise; $S_t = 1$ if t >2008Q2 and 0 otherwise. This variable has an initial value in 2008Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(3) Postal Prices**

The Standard Regular Letters equation includes a price index measuring the average price of non-parcel Standard Regular Letters (PX3R_NCR_L). The price variable is entered current and lagged up to four quarters.

**(4) Time Trend**

The Standard Regular Letters equation includes a full-sample linear trend and second linear time trend starting in 2011Q2.[18] The full-sample trend is included to capture general increases in the attractiveness of direct-mail advertising as a desirable advertising medium as well as in Standard Regular mail volume specifically relative to other direct-mail alternatives (e.g., Standard ECR mail). The second trend is introduced in 2011 to capture the lingering economic impacts of the Great Recession and increased electronic diversion, perhaps as a result of the cost pressures brought on by the recession, or as a result of increased use of new technologies such as smartphones and social media to the limited extent such usage actually replaced former direct advertising.

[18] This trend appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

**(5) Other Variables**

The Standard Regular letters equation includes several dummy and Intervention variables to reflect the impact of various one-time events and/or changes to the relative relationship between Standard Regular mail and other mail categories.

**(a) R2006-1**

A dummy variable equal to one starting with the implementation of R2006-1 rates in 2007Q3 (D_R07) is included in the Standard Regular equation. Standard ECR automation letter discounts were eliminated at this time, leading this mail to migrate from Standard ECR to Standard Regular.

**(b) 2012**

A dummy variable, D2012Q1, equal to one in 2012Q1, zero otherwise, is included in the Standard Regular equation. Another dummy variable, D2012Q2ON, which is equal to one from 2012Q2 forward, is also included in the Standard Regular demand equation. These dummies are included to account for significant unexplained declines in Standard Regular mail volume in FY 2012 that appear to be permanent.

**(c) Election Dummies**

Political campaigns are heavy users of Standard mail volume. Because of the general timing of Federal elections in only even-numbered years, the effect of elections on Standard mail volumes is not adequately modeled by seasonal variables.

Two dummy variables are included in the Standard Regular Letters demand equation to model the impact of Federal elections on Standard Regular Letters volume: D_EL4_PRES, which is equal to one in the fourth Postal quarter of Presidential election years; and D_EL1_08, which is equal to one in the first Postal quarter of Federal election years since 2008.

### (d) Seasonal Variables

Finally, the Standard Regular mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Regular Letters

The effect of these variables on Standard Regular Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Standard Regular Letters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 38630.495 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 4.04% | -0.441 | -1.73% |
| INVR | 28.89% | 0.376 | 10.01% |
| TREND | 48516519440.9% | 0.010 | 21.60% |
| D_R07 | 0.00% | 0.059 | 0.00% |
| D2012Q1 | 0.00% | -0.079 | 0.00% |
| D2012Q2ON | 171.83% | -0.136 | -12.69% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q2 | | | -0.46% |
| 2011Q2 | | | -17.61% |
| Seasonality | | | 0.73% |
| Other Factors | | | -1.28% |
| Mechanical Net Trend | | | 0.997435 |
| Base Volume | | | 38329.107 |
| Total Change in Volume | | | -0.78% |

## Standard Regular Machineable Non-Letters

The Standard Regular Machineable Non-Letters demand equation is estimated using stochastic constraints on investment and postage price, obtained from the Standard Regular (excluding parcels) Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in Standard Regular Machineable Non-Letters Equation

The Standard Regular Machineable Non-Letters demand equation models Standard Regular Machineable Non-Letters volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Investment

The relationship between Standard Regular Machineable Non-Letters volume and the economy is modeled through the inclusion of gross private domestic investment per adult (lNVR).

#### (2) Time Trends

The Standard Regular Machineable Non-Letters equation includes two linear trend Variable: a full-sample linear trend and a second trend which is estimated starting in 2007Q2.

The full-sample trend is included to capture general increases in the attractiveness of direct-mail advertising as a desirable advertising medium as well as in Standard Regular mail volume specifically relative to other direct-mail alternatives (e.g., Standard ECR mail). The second trend is introduced in 2007 due to weakness in the overall advertising industry (whose share of GDP declined considerably starting in 2007) as well as in specific industries which are heavy users of direct-mail advertising (e.g., the financial industry) due to the factors which ultimately led to the Great Recession (e.g., housing prices peaked in 2006).

**(3) Postal Prices**

The Standard Regular Machineable Non-Letters equation only contains a price index for the price of Machineable Non-Letters (PX3R_NCR_M). The price variable is entered current and lagged up to four quarters.

**(4) Interventions**

The Standard Regular Machineable Non-Letters demand equation includes a non-linear intervention variable that starts in 2008Q3 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q3 and 0 otherwise; $S_t = 1$ if t >2008Q3 and 0 otherwise. This variable has an initial value in 2008Q3 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

The intervention variable is included to capture the impact of the Great Recession on Standard Regular Machineable Non-Letters volume beyond what can be explained by the Investment variable.

### (5) Other Variables

The Standard Regular Machineable Non-Letters equation includes several dummy variables to reflect the impact of various one-time events and/or changes to the relative relationship between Standard Regular Machineable Non-Letters and other mail categories.

#### (a) R2006-1

A dummy variable equal to one starting with the implementation of R2006-1 rates in 2007Q3 (D_R07) is included in the Standard Regular Machineable Non-Letters equation. Standard ECR automation letter discounts were eliminated at this time, leading this mail to migrate from Standard ECR to Standard Regular.

#### (b) 2012

A dummy variable, D2012Q1, equal to one in 2012Q1, zero otherwise, is included in the Standard Regular Machineable Non-Letters equation. Another dummy variable, D2012Q2ON, which is equal to one from 2012Q2 forward, is also included in the Standard Regular Machineable Non-Letters demand equation.

#### (c) May, 2015, Rate Change

Standard Regular Machineable Non-Letters equation includes a dummy variable, D_R15, which is equal to one since the Postal Service's May, 2015, rate increase.

#### (d) Election Dummies

Political campaigns are heavy users of Standard mail volume. Because of the general timing of Federal elections in only even-numbered years, the effect of elections on Standard mail volumes is not adequately modeled by seasonal variables.

Two dummy variables are included in the Standard Regular Machineable Non-Letters demand equation to model the impact of Federal elections on Standard Regular Machineable Non-Letters volume: D_EL4_PRES, which is equal to one in the fourth Postal quarter of Presidential election years; and D_EL1_08, which is equal to one in the first Postal quarter of Federal election years since 2008.

### (e) Seasonal Variables

Finally, the Standard ECR mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Regular Machineable Non-Letters

The effect of these variables on Standard Regular Machineable Non-Letters volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Std Regular Machineable Non-Letters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 5832.446 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 2.98% | -0.452 | -1.32% |
| INVR | 28.89% | 0.312 | 8.25% |
| TREND | 48516519440.9% | -0.004 | -7.12% |
| D_R07 | 0.00% | -0.076 | 0.00% |
| D2012Q1 | 0.00% | -0.042 | 0.00% |
| D2012Q2ON | 171.83% | -0.092 | -8.79% |
| D_R15 | 53.43% | 0.392 | 18.27% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q3 | | | -0.74% |
| 2007Q2 | | | -35.49% |
| Seasonality | | | -1.60% |
| Other Factors | | | 0.67% |
| Mechanical Net Trend | | | 1.001332 |
| Base Volume | | | 4196.655 |
| Total Change in Volume | | | -28.05% |

## Standard Enhanced Carrier Route Mail

### 1. Explanatory Variables used in Standard ECR Mail Equation

The Standard ECR mail demand equation models Standard ECR mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Investment

The relationship between Standard ECR mail volume and the economy is modeled through the inclusion of gross private domestic investment per adult (INVR).

#### (2) Time Trends

The Standard ECR demand equation includes a full-sample time trend (TREND). The coefficient on TREND is negative, reflecting declining market share for Standard ECR volume within the general advertising market, as well as within the direct-mail advertising sub-market due to shifts from geographic targeting to consumer-specific targeting.

#### (3) Postal Prices

The Standard ECR mail equation only contains a price index for the price of Standard ECR mail (PX3R_CR). The price variable is entered current and lagged up to four quarters.

#### (4) Interventions

The Standard ECR demand equation includes a non-linear intervention variable that starts in 2008Q4 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q4 and 0 otherwise; $S_t = 1$ if t >2008Q4 and 0 otherwise. This variable has an initial value in 2008Q4 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

The intervention variable is included to capture the impact of the Great Recession on Standard ECR Mail volume beyond what can be explained by the Investment variable.

**(5) Other Variables**

The Standard ECR mail equation includes several additional variables. The first three sets of other variables reflect the impact of changes to the relative relationship between Standard Regular and ECR prices.

**(a) R97-1**

With the implementation of R97-1 rates in 1999Q2, Standard ECR basic letter rates were set greater than Standard Regular automation 5-digit letter rates, leading some mail to migrate from Standard ECR to Standard Regular.

A non-linear Intervention starting in 1999Q3 is included in the Standard ECR equation to explain this. This Intervention takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=1999Q3 and 0 otherwise; $S_t = 1$ if t >1999Q3 and 0 otherwise. This variable has an initial value in 1999Q3 of $\omega_0$, which decays toward a long-run value of $\omega_2$. A separate dummy variable for 1999Q2 (the actual quarter in which R97-1 rates took effect), D1999Q2, is also included in the Standard ECR demand equation.

**(b) R2006-1**

Standard ECR automation letter discounts were eliminated with the implementation of R2006-1 rates in 2007Q3, leading this mail to migrate from Standard ECR to Standard Regular. This migration is modeled via a dummy variable, D_R07, equal to one since the implementation of R2006-1 rates.

**(c) May, 2015, Rate Change**

Standard ECR equation includes a dummy variable, D_R15, which is equal to one since the Postal Service's May, 2015, rate increase.

**(d) Election Dummies**

Political campaigns are heavy users of Standard mail volume. Because of the general timing of Federal elections in only even-numbered years, the effect of elections on Standard mail volumes is not adequately modeled by seasonal variables.

Two such variables are included in the Standard ECR mail equation. The variable D_EL1_OFF00 has a value of one during the first Postal Quarter of off-year Federal election years since 2000, and is equal to zero otherwise. The variable D_EL3_OFF is equal to one in the third quarter of off-year Federal election years.

**(e) Seasonal Variables**

Finally, the Standard ECR mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Enhanced Carrier Route Mail

The effect of these variables on Standard ECR mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Standard ECR
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 24374.651 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 1.81% | -0.822 | -1.46% |
| INVR | 28.89% | 0.479 | 12.91% |
| TREND | 48516519440.9% | -0.002 | -4.58% |
| D1999Q2 | 0.00% | -0.080 | 0.00% |
| D_R07 | 0.00% | -0.056 | 0.00% |
| D_R15 | 53.43% | -0.064 | -2.69% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q4 | | | -8.03% |
| 1999Q3 | | | -0.00% |
| Seasonality | | | 1.93% |
| Other Factors | | | -0.34% |
| Mechanical Net Trend | | | 0.999324 |
| Base Volume | | | 24937.571 |
| Total Change in Volume | | | 2.31% |

## Standard Bulk Nonprofit Trunk Equation

For Standard Bulk Nonprofit, a single "trunk" equation is estimated which combines the following volumes: Standard Nonprofit Letters, Standard Nonprofit Non-Letters, Standard Nonprofit ECR Letters, and Standard Nonprofit ECR Non-Letters. Individual equations are then estimated independently by shape, which incorporate stochastic restrictions from this "trunk equation" in order to ensure the reasonableness of the results from the individual equations.

The trunk equation is not used directly in forecasting. Rather, the results associated with employment and postage price from the trunk equation are used as (stochastic) constraints in the individual demand equations.

### 1. Explanatory Variables used in Standard Bulk Nonprofit Trunk Equation

The Standard Bulk Nonprofit trunk equation models Standard Nonprofit mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Standard Bulk Nonprofit mail volume and the general economy is modeled through the inclusion of private employment per adult (EMPLOY).

#### (2) Postal Prices

The Standard Bulk Nonprofit trunk equation only contains a price index for the price of Standard Nonprofit mail (PX3N). The price variable is entered current and lagged up to four quarters.

**(3) Time Trend**

The Standard Bulk Nonprofit trunk equation includes a linear time trend starting at 2007Q2.[19] The trend is introduced in 2007 due to weakness in the overall advertising industry (whose share of GDP declined considerably starting in 2007) as well as in specific industries which are heavy users of direct-mail advertising (e.g., the financial industry) due to the factors which ultimately led to the Great Recession (e.g., housing prices peaked in 2006).

**(4) Interventions**

The Standard Bulk Nonprofit trunk equation demand equation includes a non-linear intervention variable that starts in 2009Q2 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2009Q2 and 0 otherwise; $S_t = 1$ if t >2009Q2 and 0 otherwise. This variable has an initial value in 2009Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

The Intervention variable is included in the Standard Bulk Nonprofit trunk equation starting in 2009Q2 to capture the extraordinary impact of the 'Great Recession' on Standard Nonprofit mail volumes. This variable has an initial value in 2009Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(5) Election Variables**

Political campaigns are heavy users of Standard Bulk Nonprofit mail volume. Because of the general timing of Federal elections in only even-numbered years, the

[19] This trend appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

effect of elections on Standard mail volumes is not adequately modeled by seasonal variables.

Four such variables are included in the Standard Bulk Nonprofit mail equation. The variables D_EL1_OFF and D_EL1_PRES00 are equal to one in the first quarter of off-year Federal election years and the 2000 Presidential election year, respectively. The variable D_EL3_PRES is equal to one in the third quarter of Presidential election years. And the variable D_EL4_PRES96 is equal to one in the fourth quarter of the 1996 Presidential election year.

**(6) Seasonal Variables**

Finally, the Standard Bulk Nonprofit trunk equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Bulk Nonprofit Trunk Equation

The effect of these variables on Standard Nonprofit mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Standard Bulk Nonprofit
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 13107.927 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 2.78% | -0.172 | -0.47% |
| EMPLOY | 4.72% | 0.510 | 2.38% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2009Q2 | | | 1.60% |
| 2007Q2 | | | -13.32% |
| Seasonality | | | 2.37% |
| Other Factors | | | -1.07% |
| Mechanical Net Trend | | | 0.997861 |
| Base Volume | | | 12626.938 |
| Total Change in Volume | | | -3.67% |

## Standard Nonprofit Letters

The Standard Nonprofit Letters demand equation is estimated using stochastic constraints on employment and postage price, obtained from the Standard Bulk Nonprofit Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in Standard Nonprofit Letters

The Standard Nonprofit mail demand equation models Standard Nonprofit Letters volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Standard Nonprofit Letters volume and the general economy is modeled through the inclusion of private employment per adult (EMPLOY).

#### (2) Postal Prices

The Standard Nonprofit Letters equation only contains a price index for the price of Standard Nonprofit mail (PX3N_NCR_L). The price variable is entered current and lagged up to four quarters.

**(3) Time Trend**

The Standard Nonprofit Letters equation includes a full-sample linear time trend and a second time trend starting in 2011Q2.[20] The full-sample trend is included to capture general increases in the attractiveness of direct-mail advertising as a desirable advertising medium as well as in Standard Nonprofit mail volume specifically relative to other direct-mail alternatives. The second trend is introduced in 2011 to capture the lingering economic impacts of the Great Recession and increased electronic diversion, perhaps as a result of the cost pressures brought on by the recession, or as a result of increased use of new technologies such as smartphones and social media to the limited extent such usage actually replaced former direct advertising.

**(4) Interventions**

The Standard Nonprofit Letters demand equation includes a non-linear intervention variable that starts in 2009Q2 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2009Q2 and 0 otherwise; $S_t = 1$ if t >2009Q2 and 0 otherwise. This variable has an initial value in 2009Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

The Intervention variable is included in the Standard Nonprofit Letters equation starting in 2009Q2 to capture the extraordinary impact of the 'Great Recession' on Standard Nonprofit Letters volumes. This variable has an initial value in 2009Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

[20] The latter of these trends appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

### (5) Other Variables

The Standard Nonprofit Letters equation includes several dummy variables to reflect the impact of various one-time events and/or changes to the relative relationship between Standard Nonprofit Letters and other mail categories.

#### (a) R2006-1

A dummy variable equal to one starting with the implementation of R2006-1 rates in 2007Q3 (D_R07) is included in the Standard Nonprofit mail equation. Standard Nonprofit ECR automation letter discounts were eliminated at this time, leading this mail to migrate from Standard Nonprofit ECR to Standard Nonprofit.

#### (b) Seasonal Variables

Finally, the Standard Nonprofit mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Nonprofit Letters

The effect of these variables on Standard Nonprofit mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Std Nonprofit Letters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 9878.091 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 0.47% | -0.110 | -0.05% |
| EMPLOY | 4.72% | 0.504 | 2.35% |
| TREND | 48516519440.9% | -0.002 | -3.39% |
| D_R07 | 0.00% | 0.061 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2009Q2 | | | 0.18% |
| 2011Q2 | | | -9.79% |
| Seasonality | | | 1.41% |
| Other Factors | | | -0.97% |
| Mechanical Net Trend | | | 0.998052 |
| Base Volume | | | 9391.568 |
| Total Change in Volume | | | -4.93% |

## Standard Nonprofit Non-Letters

The Standard Nonprofit Non-Letters demand equation is estimated using stochastic constraints on employment and postage price, obtained from the Standard Bulk Nonprofit Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in Standard Nonprofit Non-Letters

The Standard Nonprofit Non-Letters demand equation models Standard Nonprofit Non-Letters volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Standard Nonprofit mail volume and the general economy is modeled through the inclusion of private employment per adult (EMPLOY).

#### (2) Postal Prices

The Standard Nonprofit Non-Letters equation only contains a price index for the price of Standard Nonprofit mail (PX3N_NCR_NL). The price variable is entered current and lagged up to four quarters.

**(3) Time Trend**

The Standard Nonprofit Non-Letters equation includes a full-sample linear time trend and a second time trend starting in 2011Q2.[21] The full-sample trend is included to capture general increases in the attractiveness of direct-mail advertising as a desirable advertising medium as well as in Standard Nonprofit mail volume specifically relative to other direct-mail alternatives. The second trend is introduced in 2011 to capture the lingering economic impacts of the Great Recession and increased electronic diversion, perhaps as a result of the cost pressures brought on by the recession, or as a result of increased use of new technologies such as smartphones and social media to the limited extent such usage actually replaced former direct advertising.

**(4) Interventions**

The Standard Nonprofit Non-Letters demand equation includes a non-linear intervention variable that starts in 2009Q2 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2009Q2 and 0 otherwise; $S_t = 1$ if t >2009Q2 and 0 otherwise. This variable has an initial value in 2009Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

The Intervention variable is included in the Standard Nonprofit Non-Letters starting in 2009Q2 to capture the extraordinary impact of the 'Great Recession' on Standard Nonprofit mail volumes. This variable has an initial value in 2009Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

[21] The latter of these trends appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

### (5) Other Variables

There are three other sets of variables in the Standard Nonprofit Non-Letters equation.

#### (a) R2006-1

A dummy variable equal to one starting with the implementation of R2006-1 rates in 2007Q3 (D_R07) is included in the Standard Nonprofit mail equation. Standard Nonprofit ECR automation letter discounts were eliminated at this time, leading this mail to migrate from Standard Nonprofit ECR to Standard Nonprofit.

#### (b) May, 2015, Rate Change

Standard Nonprofit Non-Letters equation includes a dummy variable, D_R15, which is equal to one since the Postal Service's May, 2015, rate increase.

#### (c) Seasonal Variables

Finally, the Standard Nonprofit mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Nonprofit Non-Letters

The effect of these variables on Standard Nonprofit mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Std Nonprofit Nonletters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 1339.383 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 3.25% | -0.176 | -0.56% |
| EMPLOY | 4.72% | 0.517 | 2.42% |
| TREND | 48516519440.9% | -0.003 | -6.44% |
| D_R07 | 0.00% | -0.194 | 0.00% |
| D_R15 | 53.43% | 0.114 | 4.99% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2009Q2 | | | 0.00% |
| 2011Q2 | | | -18.55% |
| Seasonality | | | 1.84% |
| Other Factors | | | -1.46% |
| Mechanical Net Trend | | | 0.997056 |
| Base Volume | | | 1160.749 |
| Total Change in Volume | | | -13.34% |

## Standard Nonprofit ECR Letters

The Standard Nonprofit ECR Letters demand equation is estimated using stochastic constraints on employment and postage price, obtained from the Standard Bulk Nonprofit Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in Standard Nonprofit ECR Letters

The Standard Nonprofit ECR mail demand equation models Standard Nonprofit ECR Letters volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Standard Nonprofit ECR Letters volume and the general economy is modeled through the inclusion of private employment per adult (EMPLOY).

#### (2) Postal Prices

The Standard Nonprofit ECR Letters equation contains a price index for the price of Standard Nonprofit ECR letters (PX3N_CR_L). The price variable is entered current and lagged up to four quarters.

**(3) Time Trend**

The Standard Nonprofit ECR Letters equation includes a linear time trend over its full sample period.

**(4) Non-Linear Intervention Variable**

The Standard Nonprofit ECR Letters demand equation includes a non-linear intervention variable that starts in 2008Q4 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q4 and 0 otherwise; $S_t = 1$ if t >2008Q4 and 0 otherwise. This variable has an initial value in 2008Q4 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

The Intervention variable is included in the Standard Nonprofit ECR Letters starting in 2008Q4 to capture the extraordinary impact of the 'Great Recession' on Standard Nonprofit mail volumes. This variable has an initial value in 2008Q4 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(5) Other Variables**

The Standard Nonprofit ECR Letters equation includes other variables to reflect the impact of various one-time events and/or changes to the relative relationship between Standard Nonprofit ECR Letters and other mail categories.

**(a) R2006-1**

Automation discounts were eliminated for Standard Nonprofit ECR Letters with the implementation of R2006-1 rates in May, 2007 (2007PQ3). This led to the migration of much of this mail from Standard Nonprofit ECR to Standard Nonprofit Mail. This impact

of R2006-1 on Standard Nonprofit ECR Mail volume is modeled by a dummy variable, D_R07, which is equal to one since the implementation of R2006-1 rates, zero otherwise.

**(b) Seasonal Variables**

Finally, the Standard Nonprofit ECR Letters equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Nonprofit ECR Letters

The effect of these variables on Standard Nonprofit ECR Letters volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Std NP ECR Letters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 714.423 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 5.59% | -0.447 | -2.40% |
| EMPLOY | 4.72% | 0.505 | 2.36% |
| TREND | 48516519440.9% | -0.006 | -11.28% |
| D_R07 | 0.00% | -0.208 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2008Q4 | | | 19.60% |
| Seasonality | | | 2.55% |
| Other Factors | | | -1.61% |
| Mechanical Net Trend | | | 0.996765 |
| Base Volume | | | 809.854 |
| Total Change in Volume | | | 13.36% |

## Standard Nonprofit ECR Non-Letters

The Standard Nonprofit ECR Non-Letters demand equation is estimated using stochastic constraints on employment and postage price, obtained from the Standard Bulk Nonprofit Trunk Equation.

This equation is estimated in two steps. In the initial step, the coefficient on employment is stochastically constrained from the Trunk Equation but the price elasticity is freely estimated. The variance of the price elasticity from this equation is then used as the variance for the stochastic restriction on price in the final equation presented here. In effect, then, the estimated own-price elasticity becomes an average of the freely-estimated own-price elasticity from the shape equation and the own-price elasticity from the Trunk Equation.

### 1. Explanatory Variables used in Standard Nonprofit ECR Non-Letters

The Standard Nonprofit ECR mail demand equation models Standard Nonprofit ECR Non-Letters volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Standard Nonprofit ECR Non-Letters volume and the general economy is modeled through the inclusion of private employment per adult (EMPLOY).

#### (2) Postal Prices

The Standard Nonprofit ECR Non-Letters equation contains a price index for the price of Standard Nonprofit ECR Non-Letters (PX3N_CR_NL). The price variable is entered current and lagged up to four quarters.

**(3) Non-Linear Intervention Variable**

The Standard Nonprofit ECR Non-Letters demand equation includes a non-linear intervention variable that starts in 2009Q1 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2009Q1 and 0 otherwise; $S_t = 1$ if t >2009Q1 and 0 otherwise. This variable has an initial value in 2009Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(4) Other Variables**

The Standard Nonprofit ECR Non-Letters equation includes several dummy variables to reflect the impact of various one-time events and/or changes to the relative relationship between Standard Nonprofit ECR Non-Letters and other mail categories.

**(a) R2006-1**

Automation discounts were eliminated for Standard Nonprofit ECR letters with the implementation of R2006-1 rates in May, 2007 (2007PQ3). This led to the migration of much of this mail from Standard Nonprofit ECR to Standard Nonprofit Mail. This impact of R2006-1 on Standard Nonprofit ECR Mail volume is modeled by a dummy variable, D_R07, which is equal to one since the implementation of R2006-1 rates, zero otherwise.

**(b) May, 2015, Rate Change**

Standard Nonprofit ECR Non-Letters mail demand equation includes a dummy variable, D_R15, which is equal to one since the Postal Service's May, 2015, rate increase

### (c) Seasonal Variables

Finally, the Standard Nonprofit ECR Non-Letters equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Nonprofit ECR Non-Letters

The effect of these variables on Standard Nonprofit ECR Non-Letters volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Std NP ECR Non-Letters
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 1176.030 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 6.17% | -0.567 | -3.34% |
| EMPLOY | 4.72% | 0.507 | 2.36% |
| D_R07 | 0.00% | -0.058 | 0.00% |
| D_R15 | 53.43% | -0.197 | -8.07% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2009Q1 | | | -2.09% |
| Seasonality | | | 16.65% |
| Other Factors | | | -2.33% |
| Mechanical Net Trend | | | 0.995292 |
| Base Volume | | | 1264.768 |
| Total Change in Volume | | | 7.55% |

## Periodicals Mail

The Periodicals mail class is available for mail that is sent at regular intervals and contains at least a minimum level of editorial (i.e., non-advertising) content. This type of mail may include magazines, newspapers, journals, and newsletters. The Periodicals Mail class is divided into four subclasses, Periodicals Regular and three subclasses which offer preferred rates for certain eligible mailers. Periodicals Within-County mail is open to Periodicals which are sent within the same county as they are printed. Periodicals Nonprofit mail is open to Periodicals sent by qualified not-for-profit organizations. Periodicals Classroom mail is open to Periodicals sent to educational institutions for educational purposes.

### 1. Factors Affecting Demand for Periodicals

The demand for Periodicals mail is a derived demand, which is derived from the demand of consumers for magazines and newspapers. Those factors which influence the demand for newspapers and magazines would therefore be expected to be the principal drivers of the demand for Periodicals mail.

The factors which would be expected to influence the demand for newspapers and magazines are drawn from basic micro-economic theory. These factors include the state of the overall economy, the price of periodicals, and the demand for goods which may serve as substitutes for newspapers and magazines.

The Periodicals demand equation includes total private employment. Employment worked better econometrically at explaining Periodicals mail volumes than other macro-economic variables tested, including personal disposable income, consumption expenditures, and retail sales.

The price of periodicals is measured by the price of postage paid by publishers (and paid implicitly by consumers through subscription rates). In addition to affecting the price of newspapers and magazines by being incorporated into subscription rates, the

price charged by the Postal Service will also affect the demand for Periodicals mail directly by affecting publishers' decisions over how to deliver their Periodicals. For example, the delivery requirements of many weekly newspapers can be satisfied by either mail or private delivery.

The Periodicals demand equations used here also includes a long-run time trend. This long-run trend is the result of long-run demographic shifts away from reading. In addition to the full-sample linear time trend, an additional negative trend is also included in the Periodicals demand equation to account for more recent declines in Periodicals Mail volume due to increased substitution faced by Periodicals from the Internet.

A single demand equation is estimated for total Periodicals Mail.

## Periodical Regular Mail

### 1. Explanatory Variables Used in Periodicals Mail Equation

The Periodicals Mail demand equation models Periodicals mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Periodicals Mail and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the Periodicals Mail equation.

Employment is entered into the Periodical Regular Mail equation lagged one quarter.

#### (2) Non-Linear Intervention Variable

The Periodicals Mail demand equation includes a non-linear intervention variable that starts in 2008Q2 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q2 and 0 otherwise; $S_t = 1$ if t >2008Q2 and 0 otherwise. This variable has an initial value in 2008Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

As in the cases of First-Class Mail, Standard Mail, and Bound Printed Matter, the purpose of this non-linear intervention is to capture the permanent impact of the Great Recession on Periodicals Mail volume.

#### (3) Time Trends

Periodicals volumes have been in decline for the past twenty years or more. This is due, in large part, to demographic shifts away from reading toward other activities,

including television and the internet. These long-run negative trends in Periodicals volumes are modeled econometrically through the two linear time trends starting at two separate times: 2000Q1 and 2011Q2.[22]

The negative trends in Periodicals Mail volume have accelerated in recent years. In part, this is likely due to the increased use of e-readers and mobile devices such as smartphones. In addition, significant losses in advertising revenue due to the Great Recession caused many publishers to go out of business or to replace their print editions with editions available only online. The second time trend starting in 2011Q2 captures the acceleration.

**(4) Postal Prices**

The Periodicals Mail demand equation includes a price index measuring the average price of Periodicals Mail (PX2R). The price variable is entered current and lagged up to four quarters.

**(5) Other Variables**

A fairly significant shift in mail volume from Periodicals outside-county mail (especially Regular Rate Mail) to Periodicals Within-County Mail coincides with a rule change in 2007 that liberalized the eligibility for Periodical Within-County rates. A dummy variable equal to one since the 2007 rule change (RULE07) is included in the Periodical Regular Mail demand equation to capture this effect.

Finally, the Periodical regular mail equation includes a set of seasonal variables.

[22] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

## 2. Econometric Demand Equation: Periodical Regular Mail

The effect of these variables on Periodicals Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Periodical Regular Mail
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 4940.062 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 2.90% | -0.178 | -0.51% |
| EMPLOY(-1) | 4.12% | 0.996 | 4.10% |
| RULE07 | 0.00% | -0.035 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2000Q1 | | | -10.35% |
| 2008Q2 | | | -1.07% |
| 2011Q2 | | | -21.01% |
| Seasonality | | | 0.00% |
| Other Factors | | | 1.36% |
| Mechanical Net Trend | | | 1.002709 |
| Base Volume | | | 3851.202 |
| Total Change in Volume | | | -22.04% |

## Periodicals Nonprofit and Classroom

### 1. Explanatory Variables Used in Periodicals Nonprofit and Classroom Equation

The Periodicals Nonprofit and Classroom demand equation models Periodicals Nonprofit and Classroom volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Periodicals Nonprofit and Classroom and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the Periodicals Nonprofit and Classroom equation.

Employment is entered into the Periodicals Nonprofit and Classroom Mail equation lagged four quarters.

#### (2) Time Trends

Periodicals volumes have been in decline for the past twenty years or more. This is due, in large part, to demographic shifts away from reading toward other activities, including television and the internet. This long-run negative trend in Periodicals volumes is modeled econometrically through a time trend starting in 2000Q1.[23]

#### (3) Postal Prices

The Periodicals Nonprofit and Classroom Mail demand equation includes a price index measuring the average price of Periodicals Nonprofit and Classroom Mail (PX12_13). The price variable is entered current and lagged up to four quarters.

[23] This trend appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

### (4) Seasonal Variables

Finally, the Periodicals Nonprofit and Classroom equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Periodicals Nonprofit and Classroom

The effect of these variables on Periodicals Nonprofit and Classroom volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Periodical Nonprofit & Classroom
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 1633.952 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 4.90% | -0.199 | -0.95% |
| EMPLOY(-4) | -0.13% | 0.608 | -0.08% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2000Q1 | | | -16.29% |
| Seasonality | | | -0.03% |
| Other Factors | | | -1.27% |
| Mechanical Net Trend | | | 0.997441 |
| Base Volume | | | 1416.156 |
| Total Change in Volume | | | -13.33% |

## Periodicals Mail Within-County

### 1. Explanatory Variables Used in Periodicals Mail Within-County Equation

The Periodicals Mail Within-County demand equation models Periodicals mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Periodicals Mail Within-County and the general economy is modeled through the inclusion of Private Employment (EMPLOY) per adult as an explanatory variable in the Periodicals Mail equation.

#### (2) Time Trends

Periodicals volumes have been in decline for the past twenty years or more. This is due, in large part, to demographic shifts away from reading toward other activities, including television, the internet, and increased use of e-readers and mobile devices such as smartphones.

In addition, significant losses in advertising revenue due to the Great Recession caused many publishers to go out of business or to replace their print editions with editions available only online. To model this impact, a trend is added to the Periodicals Mail Within-County equation starting in 2008Q1.[24]

#### (3) Postal Prices

The Periodicals Mail demand equation includes a price index measuring the average price of Periodicals Mail (PX11). The price variable is entered current and lagged up to four quarters.

[24] This trend appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

### (4) Seasonal Variables

Finally, the Periodicals Mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Periodicals Mail Within-County

The effect of these variables on Periodicals Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Periodical Within-County
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 695.455 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 4.11% | -0.115 | -0.46% |
| EMPLOY | 4.72% | 0.858 | 4.04% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2008Q1 | | | -24.87% |
| Seasonality | | | -0.00% |
| Other Factors | | | -0.47% |
| Mechanical Net Trend | | | 0.999062 |
| Base Volume | | | 570.817 |
| Total Change in Volume | | | -17.92% |

**Package Delivery Services**

Package delivery services refer broadly to the delivery of goods other than Periodicals, advertisements, and correspondence. Examples of this type of mail include mail-order deliveries (such as clothes) and the delivery of books, tapes, or CDs, as well as packages sent by households (e.g., Christmas presents). Among market-dominant mail categories, this encompasses First-Class Parcels (which were discussed earlier) and the Package Services mail class.

The demand for package delivery services is a derived demand, emanating from the demand for the products being delivered. As such, the demand for package delivery services would be expected to be a function of the usual factors affecting demand.

Most Package Delivery Services face significant competition from other delivery firms, including United Parcel Service and FedEx. Because of this, most categories of mail that can best be described as Package Delivery Services are classified as competitive mail products and are not included as part of this report.

As of January, 2015, there were four market-dominant subclasses of mail in the Package Services class: Bound Printed Matter, Media Mail, Library Rate Mail, and Alaska Bypass. Standard (M-D) Parcels are also included in this section. The latter two of these – Alaska Bypass and Standard (M-D) Parcels – are estimated using stochastic constraints on the coefficients on e-commerce sales and price obtained from the Shipping and Package Services Trunk Equation. This trunk equation is described in the document “Narrative Explanation of Econometric Demand Equations for Competitive Products Filed with Postal Regulatory Commission on January 20, 2016”, which was filed non-publically concurrent with this document.

Bound Printed Matter refers to any mail that is bound and printed and weighs up to fifteen pounds. Generally, Bound Printed Matter falls into one of three categories: catalogs, books (including telephone books in some areas), and direct-mail advertising. The Media Mail subclass is reserved for books, tapes, and CDs. The Library Rate subclass is a preferred subclass, generally corresponding to the Media Mail subclass, available to libraries and certain other institutions. A single demand equation is estimated for the combined volume of Media Mail and Library Rate mail.

The demand for package delivery services will be largely driven by the demand for the goods being delivered. In the cases of Bound Printed Matter and Media Mail, this relationship is modeled through the inclusion of e-commerce sales as an explanatory variable.

Bound Printed Matter and Media Mail receive somewhat preferred rates from the Postal Service based on their content. Because of this, these subclasses face less price-based competition from other package delivery companies than the Postal Service's competitive mail delivery products. Because of this, competitor prices are not included in the Bound Printed Matter and Media Mail equations.

The specific demand equations for Bound Printed Matter and Media Mail are presented in more detail below.

## Standard (M-D) Parcels

The Standard Parcels demand equation is estimated using stochastic constraints on e-commerce sales and price obtained from the Shipping and Package Services Trunk Equation. This trunk equation is described in the document "Narrative Explanation of Econometric Demand Equations for Competitive Products Filed with Postal Regulatory Commission on January 20, 2016", which was filed non-publically concurrent with this document.

### 1. Explanatory Variables used in the Standard Parcels Equation

The Standard Parcels demand equation includes the following explanatory variables.

#### (1) Macro-Economic Variable: E-Commerce

Standard (M-D) Parcels volumes consist largely of products that were purchased and delivered by the sender or recipient of the mail. This type of mail volume can be thought of as deriving almost directly from either expected or actual retail sales. Online shopping (referred to as e-commerce) is growing and resulting in more packages being delivered to households and businesses. Hence, private e-commerce sales per adult (ECOMM) is included directly in the demand equation for Standard (M-D) Parcels.

#### (2) Time Trend

The Standard Parcels equation includes a full-sample linear time trend, TREND.

#### (3) Postal Prices

The Standard Parcels demand equation includes a price index for the average price of Standard Parcels (PX3_P). The price variable is entered current and lagged up to four quarters.

### (4) Other Variables

Finally, the Standard Parcels equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Standard Parcels (M-D)

The effect of these variables on Standard Parcels volume over the past two years (2014 and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Standard (M-D) Parcels
VOLUME OVER LAST TWO YEARS

| | | | |
|---|---|---|---|
| Volume 2 Years Ago | | | 72.672 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| ECOMM | 25.27% | 0.484 | 11.51% |
| TREND | 297995.80% | -0.042 | -28.25% |
| PX3_P | 8.64% | -0.508 | -4.12% |
| Adult Population | | | 2.31% |
| Seasonality | | | 49.52% |
| Other Factors | | | -28.57% |
| Mechanical Net Trend | | | 0.893891 |
| Base Volume | | | 60.907 |
| Total Change in Volume | | | -16.19% |

## Bound Printed Matter Trunk Equation

For Bound Printed Matter, a single "trunk equation" is estimated first. Individual equations are then estimated independently for Bound Printed Matter Flats and Bound Printed Matter Parcels, which incorporate stochastic restrictions from this "trunk equation" in order to ensure the reasonableness of the results from the individual equations.

The trunk equation is not used directly in forecasting. Rather, the results associated with e-commerce sales and postage price from the trunk equation are used as (stochastic) constraints in the individual demand equations.

### 1. Explanatory Variables used in Bound Printed Matter Trunk Equation

The Bound Printed Matter demand equation models Bound Printed Matter volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: E-Commerce

Bound Printed Matter volumes consist largely of catalogs as well as the delivery of products bought by the sender or recipient of the mail. In both cases, these types of mail volume can be thought of as deriving almost directly from either expected or actual retail sales. Online shopping (referred to as e-commerce) is growing and resulting in more packages being delivered to households and businesses. Hence, private e-commerce sales per adult (ECOMM) is included directly in the demand equation for Bound Printed Matter..

**(2) Intervention Variable**

The Great Recession had a significant negative impact on Bound Printed Matter mail volume that is not adequately explained by simply including e-commerce l sales (which did not fall off considerably during the Great Recession).

To capture this effect econometrically, an Intervention variable was added to the Bound Printed Matter demand equation that starts in 2008Q4 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q4 and 0 otherwise; $S_t = 1$ if t >2008Q4 and 0 otherwise. This variable has an initial value in 2008Q4 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(3) Postal Prices**

The Bound Printed Matter equation includes a price index measuring the average price of Bound Printed Matter (PX28). The price variable is entered current and lagged up to four quarters.

**(4) Seasonal Variables**

Finally, the Bound Printed Matter equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Bound Printed Matter Trunk Equation

The effect of these variables on Bound Printed Matter volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Bound Printed Matter
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 474.425 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 1.02% | -0.712 | -0.72% |
| ECOMM | 75.78% | 0.067 | 3.84% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2008Q4 | | | -10.70% |
| Seasonality | | | -0.03% |
| Other Factors | | | 5.54% |
| Mechanical Net Trend | | | 1.010840 |
| Base Volume | | | 488.404 |
| Total Change in Volume | | | 2.95% |

## Bound Printed Matter Flats

The Bound Printed Matter Flats demand equation is estimated using stochastic constraints on e-commerce sales and postage price, obtained from the Bound Printed Matter Trunk Equation.

### 1. Explanatory Variables used in Bound Printed Matter Flats

The Bound Printed Matter demand equation models Bound Printed Matter volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: E-Commerce

Bound Printed Matter Flats volumes consist largely of catalogs as well as the delivery of products bought by the sender or recipient of the mail. This type of mail volume can be thought of as deriving almost directly from either expected or actual retail sales. Online shopping (referred to as e-commerce) is growing and resulting in more packages being delivered to households and businesses. Hence, private e-commerce sales per adult (ECOMM) is included directly in the demand equation for Bound Printed Matter Flats.

#### (3) Time Trends

The Bound Printed Matter Flats demand equation includes a full-sample linear trend and a second linear time trend starting at 2012Q1.[25] The second trend is included in part to capture the effect of e-readers and mobile devices such as smartphones. This form of electronic diversion is reducing the demand for print version to be delivered to the home.

[25] This trend appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a simple linear time trend starting at the relevant time in the demand equation.

**(2) Intervention Variable**

The Great Recession had a significant negative impact on Bound Printed Matter mail volume that is not adequately explained by simply including e-commerce sales(which did not fall off considerably during the Great Recession).

To capture this effect econometrically, an Intervention variable was added to the Bound Printed Matter demand equation that starts in 2008Q4 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q4 and 0 otherwise; $S_t = 1$ if t >2008Q4 and 0 otherwise. This variable has an initial value in 2008Q4 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(3) Postal Prices**

The Bound Printed Matter equation includes a price index measuring the average price of Bound Printed Matter (PX28_F). The price variable is entered current and lagged up to four quarters.

**(4) Other Variables**

The impact of R2006-1 on Bound Printed Matter Flats mail volume is modeled by a dummy variable, D_R07, which is equal to one since the implementation of R2006-1 rates, zero otherwise.

Finally, the Bound Printed Matter equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Bound Printed Matter Flats

The effect of these variables on Bound Printed Matter volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Bound Printed Matter Flats
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 229.733 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | -2.91% | -0.697 | 2.08% |
| ECOMM | 75.78% | 0.067 | 3.86% |
| TREND | 48516519440.9% | 0.020 | 47.94% |
| D_R07 | 0.00% | -0.153 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2008Q4 | | | -24.28% |
| 2012Q1 | | | -13.64% |
| Seasonality | | | -0.00% |
| Other Factors | | | 4.31% |
| Mechanical Net Trend | | | 1.008476 |
| Base Volume | | | 260.492 |
| Total Change in Volume | | | 13.39% |

## Bound Printed Matter Parcels

The Bound Printed Matter Parcels demand equation is estimated using stochastic constraints on e-commerce sales and postage price, obtained from the Bound Printed Matter Trunk Equation.

### 1. Explanatory Variables used in Bound Printed Matter Parcels

The Bound Printed Matter demand equation models Bound Printed Matter volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: E-Commerce

Bound Printed Matter Parcels volumes consist largely of catalogs as well as the delivery of products bought by the sender or recipient of the mail. This type of mail volume can be thought of as deriving almost directly from either expected or actual retail sales. Online shopping (referred to as e-commerce) is growing and resulting in more packages being delivered to households and businesses. More specifically, Bound Printed Matter Parcels volumes are a function of online retail sales, that is, sales of goods which are delivered to the consumer. Hence, private e-commerce sales per adult (ECOMM) is included directly in the demand equation for Bound Printed Matter Parcels.

#### (2) Time Trends

The Bound Printed Matter Parcels demand equation includes one linear trend variable: a full-sample linear trend (TREND).

**(3) Intervention Variable**

The Great Recession had a significant negative impact on Bound Printed Matter mail volume that is not adequately explained by simply including e-commercesales (which did not fall off considerably during the Great Recession).

To capture this effect econometrically, an Intervention variable was added to the Bound Printed Matter demand equation that starts in 2008Q4 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2008Q4 and 0 otherwise; $S_t = 1$ if t >2008Q4 and 0 otherwise. This variable has an initial value in 2008Q4 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(4) Postal Prices**

The Bound Printed Matter equation includes a price index measuring the average price of Bound Printed Matter (PX28_P). The price variable is entered current and lagged up to four quarters.

**(5) Other Variables**

The impact of R2006-1 on Bound Printed Matter Parcels mail volume is modeled by a dummy variable, D_R07, which is equal to one since the implementation of R2006-1 rates.

Finally, the Bound Printed Matter Parcels equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Bound Printed Matter Parcels

The effect of these variables on Bound Printed Matter volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Bound Printed Matter Parcels
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 244.692 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 4.12% | -0.672 | -2.68% |
| ECOMM | 75.78% | 0.066 | 3.82% |
| TREND | 48516519440.9% | -0.006 | -10.67% |
| D_R07 | 0.00% | 0.052 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2008Q4 | | | -8.17% |
| Seasonality | | | -0.06% |
| Other Factors | | | 6.09% |
| Mechanical Net Trend | | | 1.011888 |
| Base Volume | | | 227.911 |
| Total Change in Volume | | | -6.86% |

## Media and Library Rate Mail

### 1. Explanatory Variables used in Media and Library Rate Mail Equation

The Media and Library Rate Mail demand equation models Media and Library Rate mail volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: E-Commerce

Media and Library Rate volumes consist largely of the delivery of products bought by the sender or recipient of the mail. This type of mail volume can be thought of as deriving almost directly from either expected or actual retail sales. Online shopping (referred to as e-commerce) is growing and resulting in more packages being delivered to households and businesses. Hence, private e-commerce sales per adult (ECOMM) is included directly in the demand equation for Media and Library Rate Mail..

#### (2) Trends

While e-commerce, which is a growing component of mail-order retail sales, has had a positive impact on Media and Library Rate mail volume, the Internet has also had an offsetting negative impact on Media mail volume by providing an alternative delivery source for such items as music, videos, and computer software. This negative impact has increased with the increasing availability of higher-speed Internet connections which have made it quicker and easier to download these types of things instead of having them delivered through the mail.

The Media and Library Rate mail demand equation includes two linear time trends to model this negative diversion, starting in 2003Q1 (the starting date for the Media Mail demand equation) and 2010Q1.[26] The latter of these trends may also be picking up

[26] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

ongoing negative influences of the Great Recession on Media and Library Rate mail volumes.

### (3) Postal Prices

The Media and Library Rate mail equation includes the price of Media and Library Rate Mail (PX29_30). The price variable is entered current and lagged up to four quarters.

### (4) Seasonal Variables

Finally, the Media and Library Rate Mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Media and Library Rate Mail

The effect of these variables on Media and Library Rate Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Media and Library Rate
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 120.610 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 5.95% | -0.794 | -4.49% |
| ECOMM | 75.78% | 0.303 | 18.67% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2003Q1 | | | -38.40% |
| 2010Q1 | | | -16.58% |
| Seasonality | | | -0.00% |
| Other Factors | | | 1.04% |
| Mechanical Net Trend | | | 1.002064 |
| Base Volume | | | 75.220 |
| Total Change in Volume | | | -37.63% |

## Alaska Bypass

The Alaska Bypass demand equation is estimated using stochastic constraints on e-commerce sales and price obtained from the Shipping and Package Services Trunk Equation. This trunk equation is described in the document "Narrative Explanation of Econometric Demand Equations for Competitive Products Filed with Postal Regulatory Commission on January 20, 2016", which was filed non-publically concurrent with this document.

### 1. Explanatory Variables used in the Alaska Bypass Equation

The Alaska Bypass demand equation includes the following explanatory variables.

#### (1) Macro-Economic Variable: E-Commerce

The relationship between Alaska Bypass volume and the economy is modeled through the inclusion of e-commerce sales (ECOMM) as an explanatory variable in the Alaska Bypass demand equation.

#### (2) Time Trend

The Alaska Bypass equation includes a full-sample linear time trend, TREND.

#### (3) Postal Prices

The Alaska Bypass demand equation includes a price index for the average price of Alaska Bypass (PX25_AB). The price variable is entered current and lagged up to four quarters.

### (4) Other Variables

Finally, the Alaska Bypass equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Alaska Bypass

The effect of these variables on Alaska Bypass volume over the past two years (2014 and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Alaska Bypass
VOLUME OVER LAST TWO YEARS

| | | | |
|---|---|---|---|
| Volume 2 Years Ago | | | 1.295 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| ECOMM | 25.27% | 0.477 | 11.35% |
| TREND | 297995.80% | -0.014 | -10.36% |
| PX25_AB | 6.13% | -0.503 | -2.95% |
| Adult Population | | | 2.31% |
| Seasonality | | | -2.75% |
| Other Factors | | | 2.74% |
| Mechanical Net Trend | | | 1.009063 |
| Base Volume | | | 1.282 |
| Total Change in Volume | | | -0.97% |

## Free Mail Services

There are two mail categories for which mail is free to the sender: Postal Penalty Mail, mail sent by the Postal Service, and Free-for-the-Blind Mail, which is free for blind or handicapped individuals. Because these mail categories are free, Postal prices are not included as explanatory variables in these equations. The specific demand equations used to model Postal Penalty and Free-for-the-Blind mail volumes are outlined below.

### Postal Penalty Mail

The Postal Penalty mail demand equation models Postal Penalty mail volume per adult per day as a function of the following explanatory variables.

The Postal Penalty equation includes a linear time trend, TREND. The Postal Penalty equation includes two dummy variables, D2013Q1 and D2013Q4, which are equal to one in 2013Q1 and 2013Q4, respectively, zero elsewhere. Finally, the Postal Penalty mail equation includes a set of seasonal variables.

The effect of these variables on Postal Penalty volume over the past two years (2014 and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Postal Penalty
VOLUME OVER LAST TWO YEARS

Volume 2 Years Ago 598.482

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| TREND | 297995.80% | -0.018 | -13.67% |
| D2013Q1 | -30.22% | 0.177 | -6.19% |
| D2013Q4 | -30.22% | 1.030 | -30.98% |
| Adult Population | | | 2.31% |
| Seasonality | | | 2.25% |
| Other Factors | | | 3.21% |
| Mechanical Net Trend | | | 1.010596 |
| Base Volume | | | 361.216 |
| Total Change in Volume | | | -39.64% |

## Free-for-the-Blind and Handicapped Mail

The Free-for-the-Blind Mail demand equation models Free-for-the-Blind mail volume per adult per day as a function of the following explanatory variables.

The Free-for-the-Blind demand equation includes a full-sample linear time trend, TREND, and a second time trend starting in 2008Q3.[27] In addition, the Free-for-the-Blind Mail equation includes a set of quarterly dummy variables to model seasonality.

The effect of these variables on Free-for-the-Blind Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Free-for-the-Blind
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 68.234 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| TREND | 48516519440.9% | -0.008 | -14.07% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2008Q3 | | | -19.33% |
| Seasonality | | | 0.00% |
| Other Factors | | | -9.27% |
| Mechanical Net Trend | | | 0.980734 |
| Base Volume | | | 45.484 |
| Total Change in Volume | | | -33.34% |

[27] The latter of these trends appears in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rate of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

## Ancillary and Special Services

### 1. General Overview

Ancillary services are not mail volumes, but represent add-ons to mail volumes. That is, a certified letter would be counted as both a piece of Certified Mail as well as a First-Class letter. Therefore, the volumes of ancillary services are not included in a calculation of total Postal Service volume.

Because ancillary services are add-ons to existing mail volumes, the demand for ancillary services may be affected directly by the demand for complementary categories of mail. For example, the volume of Stamped Envelopes is modeled in part as a function of the volume of First-Class Single-Piece Letters since all Stamped Envelopes are, in fact, First-Class Single-Piece Letters.

Money Orders and Post Office Boxes are considered Special Services instead of Ancillary Services. Unlike ancillary services, Money Orders and Post Office Boxes are not add-ons to mail volumes, but represent separate volume (which would, however, generally not be viewed as "mail" volume *per se*).

The ancillary and special service volumes modeled here have generally exhibited long-run trends. For this reason, a time trend is included in the demand equation associated with most of these services.

Finally, of course, the demand for ancillary and special services is also a function of the price charged by the Postal Service for these services. In addition, most of the ancillary and special service equations also include some equation-specific variables, which are described below.

Specific demand equations for ancillary and special services are described in detail below.

## Registered Mail

### 1. Explanatory Variables used in Registered Mail Equation

The Registered Mail demand equation models Registered Mail volume per adult per day as a function of the following explanatory variables.

#### (1) Time Trend

The Registered Mail equation includes a full-sample linear time trend to account for the long-run decline which is the predominant feature of Registered Mail volume.

#### (2) Postal Prices

The Registered Mail equation includes a price index measuring the average price of Registered Mail (PX35). The price variable is entered current and lagged up to four quarters.

#### (3) Dummy Variables

The Registered Mail equation contains two dummy variables, D2002Q1 and D2007Q2, which are equal to one in 2002Q1 and 2007Q2, respectively, and zero elsewhere. The first of these variables is included to measure the impact of 9/11 and the bioterrorist attack in the autumn of 2001 on Registered Mail volume. The latter variable is simply included because Registered Mail volume in 2007Q2 is something of an outlier. The Registered Mail equation includes a dummy variable, D_R15, which is equal to one since the Postal Service's May, 2015, rate increase.

#### (4) Seasonal Variables

Finally, the Registered Mail equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Registered Mail

The effect of these variables on Registered Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN Registered VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 2.967 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 3.68% | -0.312 | -1.12% |
| TREND | 48516519440.9% | -0.025 | -38.83% |
| D2002Q1 | 0.00% | -0.197 | 0.00% |
| D2007Q2 | 0.00% | 0.157 | 0.00% |
| D_R15 | 53.43% | 0.477 | 22.64% |
| Adult Population | | | 5.99% |
| Seasonality | | | 0.41% |
| Other Factors | | | 4.39% |
| Mechanical Net Trend | | | 1.008637 |
| Base Volume | | | 2.445 |
| Total Change in Volume | | | -17.59% |

## Insured Mail

### 1. Explanatory Variables used in Insured Mail Equation

The Insured Mail demand equation models Insured Mail volume per adult per day as a function of the following explanatory variables.

#### (1) Retail Package Volume

Retail package volume per adult per day (BGVOL_PKG) (which is equal to the sum of the volumes of Priority Mail, Retail Parcel Post, and Media Mail), is included as an explanatory variable in the Insured Mail equation.

#### (2) Postal Prices

The Insured Mail equation includes a price index measuring the average price of Insured Mail (PX36). The price variable is entered current and lagged up to four quarters.

#### (3) Time Trend

The Insured Mail equation includes a linear time trend, TREND, which increases by one each quarter.

#### (4) Introduction of Free Insurance for Priority Mail

The Insured Mail equation includes a dummy variable, D_FREEINS, which is set equal to one since the introduction of free insurance attached to Priority Mail, in the fourth Postal Quarter of FY 2013.

#### (5) Seasonal Variables

Finally, the Insured Mail equation includes a set of quarterly dummy variables.

## 2. Econometric Demand Equation: Insured Mail

The effect of these variables on Insured Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Insurance
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 39.719 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 9.12% | -0.315 | -2.71% |
| BGVOL_PKG | 7.66% | 0.337 | 2.52% |
| TREND | 48516519440.9% | -0.028 | -43.29% |
| D_FREEINS | 171.83% | -0.239 | -21.27% |
| Adult Population | | | 5.99% |
| Seasonality | | | -0.03% |
| Other Factors | | | -1.88% |
| Mechanical Net Trend | | | 0.996211 |
| Base Volume | | | 18.390 |
| Total Change in Volume | | | -53.70% |

## Certified Mail

### 1. Explanatory Variables used in Certified Mail Equation

The Certified Mail demand equation models Certified Mail volume per adult per day as a function of the following explanatory variables.

#### (1) Postal Prices

The Certified Mail equation includes a price index measuring the average price of Certified Mail (PX37). The price variable is entered current and lagged up to four quarters.

#### (2) Intervention Variable

The Certified Mail equation includes an Intervention variable that starts in 2011Q1 to model significant declines in Certified Mail volume that started around this time. This variable takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2011Q1 and 0 otherwise; $S_t = 1$ if t >2011Q1 and 0 otherwise. This variable has an initial value in 2011Q1 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

## 2. Econometric Demand Equation: Certified Mail

The effect of these variables on Certified Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Certified
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 282.642 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 8.62% | -0.340 | -2.77% |
| SAT_SUN | 0.00% | -0.012 | 0.00% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2011Q1 | | | -29.63% |
| Seasonality | | | -0.02% |
| Other Factors | | | -3.51% |
| Mechanical Net Trend | | | 0.992874 |
| Base Volume | | | 197.734 |
| Total Change in Volume | | | -30.04% |

## Collect-on-Delivery Mail

### 1. Explanatory Variables used in COD Mail Equation

The COD Mail demand equation models COD Mail volume per adult per day as a function of the following explanatory variables.

#### (1) Retail Package Volumes

COD Mail volume is not stand-alone mail, but instead is an add-on to other types of mail. Generally, the type of mail that might be sent via COD is retail package mail. Retail package volume per adult per day (BGVOL_PKG) (which is equal to the sum of the volumes of Priority Mail, Retail Parcel Post, and Media Mail (all per adult per Postal day)), is included as an explanatory variable in the COD Mail equation.

#### (2) Time Trends

The COD Mail demand equation includes a linear time trend (TREND) and a second time trend starting in 2012Q4.[28]

#### (3) Other Variables

Finally, the COD Mail equation includes dummy variables equal to one in 2005Q1 (D2005Q1) and 2005Q2 (D2005Q2), zero elsewhere; a dummy variable equal to one since 2012Q4 (D2012Q4ON); and a set of quarterly dummy variables.

The COD Mail demand equation includes a dummy variable, D_R15, which is equal to one since the Postal Service's May, 2015, rate increase.

Finally, the COD Mail demand equation includes a set of seasonal variables.

[28] The latter of these trends appear in the econometric output as an "Intervention" variable, where the pulse, step, and attenuation rate of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

## 2. Econometric Demand Equation: COD Mail

The effect of these variables on COD Mail volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN COD VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 0.834 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| BGVOL_PKG | 7.66% | 0.727 | 5.51% |
| TREND | 48516519440.9% | -0.026 | -41.04% |
| D2005Q1 | 0.00% | -0.137 | 0.00% |
| D2005Q2 | 0.00% | -0.219 | 0.00% |
| D2012Q4ON | 171.83% | -0.063 | -6.15% |
| D_R15 | 53.43% | 0.629 | 30.92% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2012Q4 | | | -52.43% |
| Seasonality | | | -3.92% |
| Other Factors | | | 3.28% |
| Mechanical Net Trend | | | 1.006480 |
| Base Volume | | | 0.319 |
| Total Change in Volume | | | -61.76% |

## Money Orders

### 1. Explanatory Variables used in Money Orders Equation

The Money Orders demand equation models Money Orders volume per adult per day as a function of the following explanatory variables.

#### (1) Macro-Economic Variable: Employment

The relationship between Money Orders volume and the general economy is modeled by including private Employment per adult (EMPLOY) in the Money Orders demand equation.

#### (2) Time Trends

Money Orders volume has been down significantly and consistently since late 2000. The likely cause of this downturn is increasing competition from electronic alternatives, such as pre-paid debit cards, as well as from alternate suppliers of money orders. Long-run trends in Money Orders volume also appear to have been affected by the Great Recession.

To account for these factors, the Money Orders equation includes linear time trends starting in 2002Q1 (the starting date of the Money Orders sample period) and 2011Q1.[29]

#### (3) Postal Prices

The Money Orders equation includes a price index measuring the average price of Money Orders (PX39). The price variable is entered current and lagged up to four quarters.

[29] These trends appear in the econometric output as "Intervention" variables, where the pulse, step, and attenuation rates of Intervention are constrained to be equal to zero. The result is mathematically identical, then, to including a linear time trend starting at the relevant time in the demand equation.

### (4) Other Variables

Finally, the Money Orders equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Money Orders

The effect of these variables on Money Orders volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Money Orders
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 123.405 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 4.04% | -0.227 | -0.89% |
| EMPLOY | 4.72% | 0.940 | 4.43% |
| Adult Population | | | 5.99% |
| Interventions Starting in: | | | |
| 2002Q1 | | | -28.79% |
| 2011Q1 | | | -3.04% |
| Seasonality | | | -0.65% |
| Other Factors | | | -0.09% |
| Mechanical Net Trend | | | 0.999823 |
| Base Volume | | | 92.776 |
| Total Change in Volume | | | -24.82% |

## Return Receipts

### 1. Explanatory Variables used in Return Receipts Equation

The Return Receipts demand equation models Return Receipts volume per adult per day as a function of the following explanatory variables.

#### (1) Certified Mail Volume

Return Receipts must be attached to Express Mail or one of Certified, Insured, or COD Mail. The vast majority of Return Receipts are attached to Certified Mail. Because of this, the Return Receipts demand equation includes the volume of Certified Mail per adult per day (BGVOL37) as an explanatory variable.

#### (2) Postal Prices

The Return Receipts demand equation includes a price index measuring the average price of Return Receipts (PX_RR). The price variable is entered current and lagged up to four quarters.

#### (3) Non-Linear Intervention Variable

The Return Receipts demand equation includes a non-linear intervention variable that starts in 2009Q2 and takes the following form:

$$Ln(Vol)_t = a + \ldots + \omega_0 \cdot P_t + \omega_1 \cdot (P_t + \delta P_{t-1} + \delta^2 P_{t-2} + \delta^3 P_{t-3} + \ldots) + \omega_2 \cdot S_t + \ldots$$

where $P_t$ is a pulse function and $S_t$ is a step function, so that $P_t = 1$ if t=2009Q2 and 0 otherwise; $S_t = 1$ if t >2009Q2 and 0 otherwise. This variable has an initial value in 2009Q2 of $\omega_0$, which decays toward a long-run value of $\omega_2$.

**(4) Dummy Variables**

The Return Receipts demand equation includes four dummy variables: D_MEPS, D1995Q2, D1997Q2, and D_R14. The first of these, D_MEPS, is equal to zero through 1995Q1 and is equal to one from 1995Q2 forward. There was a change in the RPW system of reporting volumes in 1995Q2, with the new system being called MEPS (Mail Exit-Point System). Possibly because of this, there was a significant increase in the reported volume of Return Receipts after 1995Q2 as compared to before 1995Q2. This is accounted for by the inclusion of D_MEPS in the Return Receipts demand equation.

The second and third dummy variables both have a value of one in only one quarter: 1995Q2 and 1997Q2, respectively. These dummy variables are included to control for anomalous Return Receipt volumes in these two quarters.

The dummy variable is D_R14 is equal to one since the Postal Service's January, 2014, rate change.

**(5) Seasonal Variables**

Finally, the Return Receipts equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Return Receipts

The effect of these variables on Return Receipts volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Return Receipts
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 223.250 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| Own-Price | 9.67% | -0.021 | -0.20% |
| BGVOL37 | -33.99% | 0.839 | -29.41% |
| D_MEPS | 0.00% | 0.102 | 0.00% |
| D1995Q2 | 0.00% | 0.322 | 0.00% |
| D1997Q2 | 0.00% | 0.220 | 0.00% |
| D_R14 | 171.83% | 0.144 | 15.52% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2009Q2 | | | -20.65% |
| Seasonality | | | 0.04% |
| Other Factors | | | 2.40% |
| Mechanical Net Trend | | | 1.004749 |
| Base Volume | | | 156.507 |
| Total Change in Volume | | | -29.90% |

## Post Office Boxes

### 1. Explanatory Variables used in Post Office Boxes Equation

The Post Office Boxes demand equation models Post Office Box volume per adult per day as a function of the following explanatory variables.

#### (1) Time Trend

The Post Office Boxes demand equation includes a linear time trend over its full sample period.

#### (2) Postal Prices

The Post Office Box equation includes a price index measuring the average price of Post Office Boxes (PX_PO). The price variable is entered current and lagged up to four quarters.

#### (3) Dummy Variables

Four dummy variables equal to one in the respective quarter and zero elsewhere, are included in the Post Office Boxes equation. These are 2009Q2, (D2009Q2), 2012Q2 (D2012Q2), 2012Q3 (D2012Q3), and 2014Q2 (D2014Q2). The equation also includes a dummy variable equal to one since the implementation of new rates in January, 2012 (D_R12).

The Post Office Boxes demand equation includes a dummy variable, D_R15, which is equal to one since the Postal Service's May, 2015, rate increase.

In addition, the Post Office Boxes equation includes a set of seasonal variables.

## 2. Econometric Demand Equation: Post Office Boxes

The effect of these variables on Post Office Boxes volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Post Office Boxes
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 57.810

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| Own-Price | -74.17% | -0.551 | 110.82% |
| TREND | 48516519440.9% | -0.008 | -14.17% |
| D2009Q2 | 0.00% | 0.038 | 0.00% |
| D2012Q2 | 0.00% | -0.151 | 0.00% |
| D2012Q3 | 0.00% | -0.035 | 0.00% |
| D_R12 | 171.83% | -0.802 | -55.18% |
| D2014Q2 | 0.00% | -0.012 | 0.00% |
| D_R15 | 53.43% | -0.042 | -1.77% |
| Adult Population | | | 5.99% |
| Seasonality | | | 0.41% |
| Other Factors | | | -0.94% |
| Mechanical Net Trend | | | 0.998119 |
| Base Volume | | | 48.554 |
| Total Change in Volume | | | -16.01% |

## Stamped Envelopes

### 1. Explanatory Variables used in Stamped Envelopes Equation

The Stamped Envelopes demand equation includes only one non-seasonal, non-dummy explanatory variable: the volume of First-Class Single-Piece letters (per adult, per day) (BGVOL01SP_L). In addition, the Stamped Envelopes equation includes a set of seasonal variables.

### 2. Econometric Demand Equation: Stamped Envelopes

The effect of these variables on Stamped Envelopes volume over the past five years (2011, 2012, 2013, 2014, and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Stamped Envelopes
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 467.617 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| BGVOL01SP_L | -32.03% | 1.534 | -44.68% |
| Adult Population | | | 5.99% |
| Seasonality | | | -0.62% |
| Other Factors | | | 3.00% |
| Mechanical Net Trend | | | 1.005923 |
| Base Volume | | | 280.634 |
| Total Change in Volume | | | -39.99% |

## Stamped Cards

### 1. Explanatory Variables used in Stamped Cards Equation

The Stamped Cards demand equation includes a dummy variable for 2015Q2 and a set of seasonal variables.

### 2. Econometric Demand Equation: Stamped Cards

The effect of these variables on Stamped Cards volume over the past two years (2014 and 2015) is shown in the table below.

CONTRIBUTIONS TO CHANGE IN
Stamped Cards
VOLUME OVER LAST TWO YEARS

| | | | |
|---|---|---|---|
| Volume 2 Years Ago | | | 0.642 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| D2015Q2 | 42.37% | -2.419 | -57.45% |
| Adult Population | | | 2.31% |
| Seasonality | | | 32.19% |
| Other Factors | | | 37.99% |
| Mechanical Net Trend | | | 1.113316 |
| Base Volume | | | 0.510 |
| Total Change in Volume | | | -20.60% |

## Delivery and Signature Confirmation

### 1. Dependent Variables used in Delivery and Signature Confirmation Equations

Delivery and Signature Confirmation volumes are divided into 14 distinct categories which distinguish Delivery Confirmation from Signature Confirmation, retail confirmation from electronic confirmation, and which distinguishes by the class of the parent piece of mail being confirmed. This produces the following 14 distinct products:

Delivery Confirmation
- Retail
  - First-Class
  - Priority
  - Package Services
- Electronic
  - First-Class
  - Priority
  - Standard
  - Parcel Select
  - Package Services

Signature Confirmation
- Retail
  - First-Class
  - Priority
  - Package Services
- Electronic
  - First-Class
  - Priority
  - Package Services

A separate demand equation is then estimated for each of these 14 products. The dependent variables in these equations are set equal to the percentage of total volume to which the relevant Confirmation service is attached, e.g., the dependent variable in the First-Class Retail Delivery Confirmation demand equation is First-Class Retail Delivery Confirmation volume divided by the total volume of First-Class parcels.

### 2. Explanatory Variables Used in Delivery and Signature Confirmation Equations

The Delivery and Signature Confirmation demand equations generally include the following explanatory variables.

#### (1) Time Trend

Delivery and Signature Confirmation volume in its earliest years was characterized by dramatic volume increases which decreased in intensity over time. To capture this, the Delivery and Signature Confirmation demand equations typically include a logistic time trend (T_DC).

#### (2) Other Variables

Some of the Delivery and Signature Confirmation equations contain one or more dummy variables reflecting either anomalous individual quarters or level shifts, typically tied to rate changes. All of the Delivery and Signature Confirmation demand equations also include quarterly dummy variables.

### 3. Econometric Demand Equations: Delivery and Signature Confirmation

The effect of these variables on Delivery and Signature Confirmation volume shares over the past five years (2011, 2012, 2013, 2014, and 2015) are shown below (for those equations for which the equation's sample period extends back that far).

CONTRIBUTIONS TO CHANGE IN
Del Conf - Retail First-Class
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 2917.446 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| D_R11 | 171.83% | 0.616 | 85.16% |
| D_R12 | 171.83% | 0.516 | 67.53% |
| D2012Q1 | 0.00% | 0.190 | 0.00% |
| D2013Q1ON | 171.83% | -0.121 | -11.39% |
| D2014Q1 | 0.00% | 1.372 | 0.00% |
| D2014Q2 | 0.00% | 1.029 | 0.00% |
| D2015Q3 | 42.84% | -0.345 | -11.57% |
| Adult Population | | | 5.99% |
| Seasonality | | | 5.04% |
| Other Factors | | | 0.74% |
| Mechanical Net Trend | | | 1.001466 |
| Base Volume | | | 7953.356 |
| Total Change in Volume | | | 172.61% |

CONTRIBUTIONS TO CHANGE IN
Del Conf - Retail Priority
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 7010.241 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| D2013Q1 | 0.00% | -0.143 | 0.00% |
| D_R13 | 171.83% | 0.782 | 118.51% |
| D2015Q3 | 42.84% | -0.309 | -10.43% |
| Adult Population | | | 5.99% |
| Seasonality | | | 4.46% |
| Other Factors | | | 2.23% |
| Mechanical Net Trend | | | 1.004423 |
| Base Volume | | | 15529.167 |
| Total Change in Volume | | | 121.52% |

CONTRIBUTIONS TO CHANGE IN
Del Conf - Retail Package Svcs
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 1733.171

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| D_R08 | 0.00% | 0.240 | 0.00% |
| D2013Q1 | 0.00% | -1.488 | 0.00% |
| D_R13 | 171.83% | 0.858 | 135.91% |
| D_R14 | 171.83% | -0.660 | -48.33% |
| Adult Population | | | 5.99% |
| Seasonality | | | -0.00% |
| Other Factors | | | 4.87% |
| Mechanical Net Trend | | | 1.009546 |
| Base Volume | | | 2348.128 |
| Total Change in Volume | | | 35.48% |

CONTRIBUTIONS TO CHANGE IN
Del Conf - Electronic First-Class
VOLUME OVER LAST TWO YEARS

Volume 2 Years Ago 83619.950

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| D2012Q4 | 0.00% | -1.899 | 0.00% |
| D2012Q4ON | 0.00% | 0.603 | 0.00% |
| Adult Population | | | 2.31% |
| Seasonality | | | -3.56% |
| Other Factors | | | 0.80% |
| Mechanical Net Trend | | | 1.002644 |
| Base Volume | | | 83160.490 |
| Total Change in Volume | | | -0.55% |

CONTRIBUTIONS TO CHANGE IN
Del Conf - Electronic Priority
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 23562.429

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| T_DC | 47.06% | 0.914 | 42.23% |
| D_R09 | 0.00% | -0.116 | 0.00% |
| D2011Q2ON | 171.83% | -0.416 | -34.06% |
| D2012Q4 | 0.00% | -1.361 | 0.00% |
| D2012Q4ON | 171.83% | 0.628 | 87.45% |
| Adult Population | | | 5.99% |
| Seasonality | | | -0.01% |
| Other Factors | | | 6.18% |
| Mechanical Net Trend | | | 1.012060 |
| Base Volume | | | 46615.505 |
| Total Change in Volume | | | 97.84% |

CONTRIBUTIONS TO CHANGE IN
Del Conf - Electronic Standard
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 23758.552

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| T_DC | 47.06% | 2.455 | 157.72% |
| D_R08 | 0.00% | 0.323 | 0.00% |
| D2012Q2 | 0.00% | -0.689 | 0.00% |
| D_R12 | 171.83% | 0.340 | 40.46% |
| D2013Q1 | 0.00% | -0.504 | 0.00% |
| Adult Population | | | 5.99% |
| Seasonality | | | 0.00% |
| Other Factors | | | -12.70% |
| Mechanical Net Trend | | | 0.973204 |
| Base Volume | | | 79583.384 |
| Total Change in Volume | | | 234.97% |

CONTRIBUTIONS TO CHANGE IN
Del Conf - Electronic Parcel Select
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 77638.458

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| T_DC | 47.06% | 0.121 | 4.78% |
| D2007Q3 | 0.00% | 0.110 | 0.00% |
| D2007Q4 | 0.00% | 0.229 | 0.00% |
| Adult Population | | | 5.99% |
| Seasonality | | | 0.00% |
| Other Factors | | | -1.14% |
| Mechanical Net Trend | | | 0.997703 |
| Base Volume | | | 85234.677 |
| Total Change in Volume | | | 9.78% |

CONTRIBUTIONS TO CHANGE IN
Del Conf - Electronic Pckg Svcs
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 64460.218

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| T_DC | 47.06% | 1.737 | 95.37% |
| D_R09 | 0.00% | 0.336 | 0.00% |
| D2013Q1ON | 171.83% | -1.389 | -75.06% |
| D_R15 | 53.43% | 0.457 | 21.61% |
| Adult Population | | | 5.99% |
| Seasonality | | | -2.40% |
| Other Factors | | | 0.09% |
| Mechanical Net Trend | | | 1.000172 |
| Base Volume | | | 39554.657 |
| Total Change in Volume | | | -38.64% |

CONTRIBUTIONS TO CHANGE IN
Sig Conf - Retail First-Class
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 173.581 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| T_DC | 47.06% | 0.654 | 28.67% |
| D2006Q1 | 0.00% | 0.248 | 0.00% |
| D2009Q4 | 0.00% | 0.290 | 0.00% |
| D2011Q4 | 0.00% | 0.505 | 0.00% |
| D_R12 | 171.83% | 2.164 | 770.60% |
| D2014Q1 | 0.00% | -0.851 | 0.00% |
| D2014Q2ON | 171.83% | -1.969 | -86.04% |
| Adult Population | | | 5.99% |
| Seasonality | | | -0.01% |
| Other Factors | | | 13.27% |
| Mechanical Net Trend | | | 1.025238 |
| Base Volume | | | 325.744 |
| Total Change in Volume | | | 87.66% |

CONTRIBUTIONS TO CHANGE IN
Sig Conf - Retail Priority
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 373.026 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| T_DC | 47.06% | 0.947 | 44.07% |
| D_R12 | 171.83% | 1.099 | 200.10% |
| D2013Q1_2 | 0.00% | 0.251 | 0.00% |
| D2013Q3 | 0.00% | 0.457 | 0.00% |
| D2014Q2ON | 171.83% | -1.141 | -68.04% |
| Adult Population | | | 5.99% |
| Interventions Starting in: 2006Q3 | | | -48.18% |
| Seasonality | | | -0.02% |
| Other Factors | | | 0.53% |
| Mechanical Net Trend | | | 1.001053 |
| Base Volume | | | 284.584 |
| Total Change in Volume | | | -23.71% |

CONTRIBUTIONS TO CHANGE IN
Sig Conf - Retail Pkg Svcs
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 45.006

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| D_R12 | 171.83% | 0.563 | 75.54% |
| D2014Q2ON | 171.83% | -1.134 | -67.83% |
| D_R15 | 53.43% | -0.955 | -33.56% |
| Adult Population | | | 5.99% |
| Seasonality | | | 15.62% |
| Other Factors | | | -3.09% |
| Mechanical Net Trend | | | 0.993744 |
| Base Volume | | | 20.055 |
| Total Change in Volume | | | -55.44% |

CONTRIBUTIONS TO CHANGE IN
Sig Conf - Electronic First-Class
VOLUME OVER LAST FIVE YEARS

Volume 5 Years Ago 602.523

| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
|---|---|---|---|
| T_DC | 47.06% | 1.967 | 113.55% |
| D_R11 | 171.83% | 0.687 | 98.80% |
| D_R14 | 171.83% | 0.333 | 39.47% |
| Adult Population | | | 5.99% |
| Seasonality | | | -0.08% |
| Other Factors | | | 11.66% |
| Mechanical Net Trend | | | 1.022294 |
| Base Volume | | | 4218.219 |
| Total Change in Volume | | | 600.09% |

CONTRIBUTIONS TO CHANGE IN
Sig Conf - Electronic Priority
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 638.572 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| T_DC | 47.06% | 1.319 | 66.32% |
| D2012Q3 | 0.00% | -0.546 | 0.00% |
| D2012Q4ON | 171.83% | -1.222 | -70.52% |
| D2014Q2ON | 171.83% | 1.241 | 245.96% |
| Adult Population | | | 5.99% |
| Seasonality | | | -0.02% |
| Other Factors | | | -1.33% |
| Mechanical Net Trend | | | 0.997324 |
| Base Volume | | | 1132.427 |
| Total Change in Volume | | | 77.34% |

CONTRIBUTIONS TO CHANGE IN
Sig Conf - Electronic Pkg Svcs
VOLUME OVER LAST FIVE YEARS

| | | | |
|---|---|---|---|
| Volume 5 Years Ago | | | 38.988 |
| Variable | Percent Change In Variable | Elasticity | Effect of Variable on Volume |
| D2008Q4 | 0.00% | 0.486 | 0.00% |
| D2012Q1 | 0.00% | 0.922 | 0.00% |
| D_R12 | 171.83% | -0.588 | -44.43% |
| D2013 | 0.00% | -0.634 | 0.00% |
| Adult Population | | | 5.99% |
| Seasonality | | | 0.00% |
| Other Factors | | | 0.27% |
| Mechanical Net Trend | | | 1.000538 |
| Base Volume | | | 23.023 |
| Total Change in Volume | | | -40.95% |